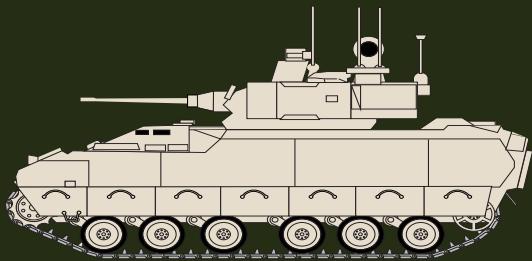
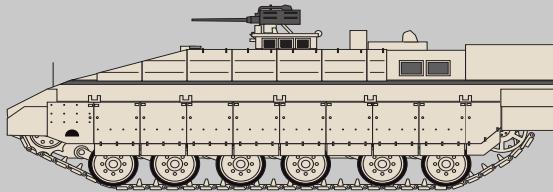


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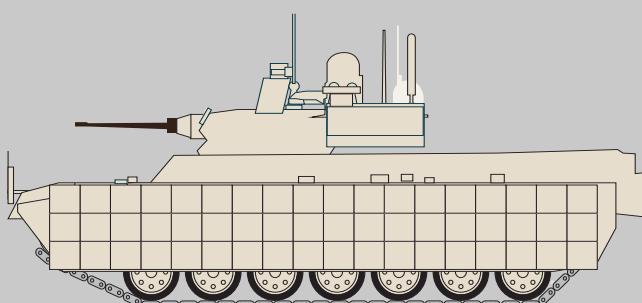
## The Army's Ground Combat Vehicle Program and Alternatives



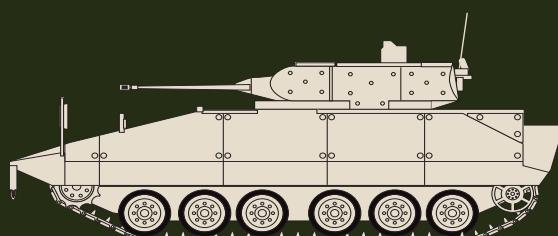
Current and Upgraded  
Bradley Infantry Fighting Vehicle



Israeli Namer Armored Personnel Carrier



Notional Ground Combat Vehicle



German Puma Infantry Fighting Vehicle

APRIL 2013

<b>Report Documentation Page</b>			<i>Form Approved OMB No. 0704-0188</i>	
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1. REPORT DATE <b>APR 2013</b>	2. REPORT TYPE	3. DATES COVERED <b>00-00-2013 to 00-00-2013</b>		
4. TITLE AND SUBTITLE <b>The Army's Ground Combat Vehicle Program and Alternatives</b>			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Congressional Budget Office (CBO),Ford House Office Building, 4th Floor ,Second and D Streets, SW ,Washington,DC,20515-6925</b>			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>				
13. SUPPLEMENTARY NOTES				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>41</b>
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>	19a. NAME OF RESPONSIBLE PERSON	

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## Notes

Numbers in the text, tables, and figures may not add up to totals because of rounding.

Unless otherwise noted, all years are federal fiscal years, which run from October 1 to September 30, and all dollars are 2013 dollars.

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# Contents

## 1

<b>Summary</b>	<b>1</b>
What Are the Program’s Objectives?	1
What Are the Program’s Challenges?	1
What Alternatives Did CBO Analyze?	1
How Were Differences Assessed?	3
Which Vehicles Would Be Most Capable?	3

## 2

<b>The Army’s Ground Combat Vehicle Program</b>	<b>5</b>
The Army’s Rationale and Goals for a New Infantry Fighting Vehicle	5
BOX: THE ARMY’S EMPHASIS ON TRANSPORTING FULL NINE-MEMBER SQUADS	6
Concerns About the GCV Program	12
<b>Alternatives to the Ground Combat Vehicle Program</b>	<b>19</b>
Option 1: Purchase the Israeli Namer APC	21
Option 2: Upgrade the Bradley IFV	26
Option 3: Purchase the German Puma IFV	28
Option 4: Cancel the GCV Program	30
<b>Appendix: CBO’s Methodology for Comparing the Army’s Ground Combat Vehicle and Alternatives</b>	<b>33</b>

<b>List of Tables and Figures</b>	<b>36</b>
-----------------------------------	-----------

<b>About This Document</b>	<b>37</b>
----------------------------	-----------





## Summary

**T**he Army is planning to develop and purchase a new Ground Combat Vehicle (GCV) that will serve the dual purposes of operating as a combat vehicle and transporting soldiers to, from, and around the battlefield. The GCV is intended to replace the current fleet of Bradley Infantry Fighting Vehicles (IFVs), which operate with the service's armored combat brigades. The Congressional Budget Office (CBO) estimates that implementing the GCV program on the most recent schedule would cost \$29 billion (in 2013 dollars) over the 2014–2030 period.

This report compares the Army's plan for the GCV with four other options the service could pursue instead. Although none of those alternatives would meet all of the Army's goals for the GCV program, all are likely to be less costly and less risky (in terms of unanticipated cost increases and schedule delays) than CBO anticipates will be the case under the Army's plan. Some of the options also would offer advantages relative to the GCV in meeting the Army's mission.

### What Are the Program's Objectives?

The search for a new GCV has forced the Army to find a balance among several objectives. While staying within prescribed costs per vehicle, the service hopes to field a fleet that will offer improvements over the current Bradley IFVs in several areas:

- Protection against threats coming from all directions and ability to operate after an attack,
- Effectiveness as a weapon against enemy forces,
- Mobility on- and off-road, and
- Capacity for a full nine-member infantry squad along with a vehicle crew of three.

Seating capacity for nine passengers is among the Army's highest priorities for the vehicle. If a squad is dispersed among several vehicles, as is the practice for units equipped with the current Bradley IFV (which

accommodates only seven soldiers), it can be difficult for leaders to organize and direct the soldiers immediately after they exit the vehicle, especially if the forces are under fire.

### What Are the Program's Challenges?

The trade-off for providing better protection and the ability to accommodate more passengers typically is a larger and heavier vehicle. Other objectives for the vehicle, such as reduced cost and better maneuverability in urban settings, are more easily met with smaller and lighter vehicles. Although the Army's program allows contractors some flexibility in meeting various goals, initial designs indicate that the GCV is likely to be much larger and heavier than the current Bradley IFV (see Summary Table 1).

Whether the GCV that results from the design process will be well suited to a range of potential future operations is not known. The vehicle as envisioned should provide improved protection against mines and improvised explosive devices—the most prevalent threat in operations such as those recently undertaken in Iraq and Afghanistan. However, several Army officials have said that vehicles that are as large and as heavy as the GCV is likely to be are not well suited to operate in situations that were common in Iraq and Afghanistan and that are likely to be faced in the future.

### What Alternatives Did CBO Analyze?

CBO analyzed four alternatives to the GCV program. For comparison with those alternatives, the agency used the characteristics of the Army's notional model (known as the GCV Design Concept After Trades vehicle).<sup>1</sup>

1. The Army intends to change the requirements for the amount of protection and the size of the GCV's primary weapon. The schedule also has been delayed, and the final choice of contractor is to occur sooner than originally planned. CBO's analysis incorporates those timing changes but could not account for changes in protection and weapons, because the details are still pending.

**Summary Table 1.****Vehicles Considered in the Army's Plan and CBO's Options**

Vehicle	Weight <sup>a</sup> (Tons)	Number of Passengers	Army's Estimate of Unit Cost <sup>b</sup> (Millions of 2013 dollars)	Year of Entry Into Service
<b>Vehicles Requiring Development</b>				
Ground Combat Vehicle <sup>c</sup>	50 to 65	9	13.5 <sup>d</sup>	2022 <sup>e</sup>
Upgraded Bradley IFV	35 to 41	7	9.6	2022
<b>Existing Vehicles</b>				
Current Bradley IFV <sup>f</sup>	33 to 39	7	n.a.	2006
Israeli Namer APC	68 to 70	9	11.0	2008
German Puma IFV	35 to 47	6	6.9	2011

Source: Congressional Budget Office based on Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives* (March 2011), and other sources.

Note: IFV = infantry fighting vehicle; APC = armored personnel carrier; n.a. = not applicable.

- a. The lower end of the range represents the weight of the vehicle without added armor or other protective measures. The upper end of the range includes the weight of currently proposed protective equipment that could be or has been added to the vehicle.
- b. Amounts are the Army's estimates of the average procurement unit cost, which excludes development cost.
- c. Based on the December 2010 version—the Design Concept After Trades—of the Ground Combat Vehicle after additional design trade-offs that the Army made to reduce the average procurement unit cost to \$13.5 million (in 2013 dollars).
- d. The unit cost is capped at \$13.0 million in 2011 dollars, or \$13.5 million in 2013 dollars.
- e. According to the Army's current plans.
- f. Version of the M2A3 Bradley IFV used in Iraq, which includes reactive armor and underbelly armor.

**Option 1: Purchase the Namer APC**

If the Army replaced its current IFV with the Israeli Namer armored personnel carrier (APC), soldiers and vehicles would probably survive combat at slightly higher rates than would be the case for the GCV. Moreover, the Namer, like the GCV, could carry a nine-member squad, although it would be less lethal (that is, have less capability to destroy enemy forces) and less mobile than the GCV. The Namer probably would be produced, at least in part, in the United States, but its fielding would nevertheless require collaboration with foreign companies and governments.

**Option 2: Upgrade the Bradley IFV**

An upgraded Bradley IFV would be more lethal than the GCV against enemy forces and would probably allow soldiers and vehicles to survive combat at about the same rates as would the GCV. But like the current model, the upgraded Bradley would carry only seven passengers—

two fewer than the Army's desired nine—and it would not be as mobile as the GCV.

**Option 3: Purchase the Puma IFV**

If the Army chose the German Puma, which carries just six passengers, to replace the current Bradley IFVs, the service would need to buy five vehicles for every four of its current Bradley IFVs. The advantage of the Puma, however, is that its capabilities are expected to be similar to or better than those of the GCV in other areas. It would be much more lethal than other vehicles that CBO evaluated—including the GCV. Its ability to protect passengers and survive combat would be slightly better than the GCV's and it would be almost as mobile. If the Army decided to field the Puma, the development and production of that vehicle, like the Namer, would require collaboration with foreign companies and governments.

**Option 4: Cancel the GCV**

If the Army reconditioned its current Bradley IFVs instead of replacing them, the current capability of the

**Summary Table 2.****Capacity, Risk, Cost, and Overall Improvement in Capability Associated with the Army's Plan and CBO's Options**

	Ability to Carry a Full Nine-Member Squad	Programmatic Risk	Total Cost, 2014–2030 <sup>b</sup> (Billions of 2013 dollars)	Overall Improvement in Combat Vehicle Capability <sup>a</sup> (Percent)	
				Primary Metric <sup>c</sup>	Secondary Metric <sup>d</sup>
Army's Plan (Field the GCV)	Yes	High	28.8	16 <sup>e</sup>	36 <sup>e</sup>
CBO's Options					
1. Purchase Israeli Namer APC	Yes	Low	19.5	6	25
2. Upgrade Bradley IFV	No	Intermediate	19.5	32	25
3. Purchase German Puma IFV	No	Low	14.5	45	38
4. Retain current Bradley IFV	No	None	4.6	0	0

Source: Congressional Budget Office.

Note: GCV = Ground Combat Vehicle; APC = armored personnel carrier; IFV = infantry fighting vehicle.

- a. The overall improvement in capability relative to the current Bradley IFV. CBO's analysis of such improvements was based on the Army's analysis and data. See the appendix for a description of CBO's methods for calculating overall improvement.
- b. For the GCV program and Options 1 and 2, the total cost covers development and purchase of 1,748 vehicles. For Option 3, the total cost covers development and purchase of 2,048 vehicles. For Option 4, the cost is the amount needed to extend the life of the Army's current Bradley IFVs and to continue research and development.
- c. CBO's primary metric determines the overall improvement in capability based on the weighting (derived from the Army's analysis) of improvements in four areas: protection and survivability (40 percent), lethality (30 percent), mobility (20 percent), and maximum number of passengers (10 percent). See the appendix for details concerning CBO's metrics.
- d. CBO's secondary metric gives equal weight to the improvement in each of the four areas in order to determine an overall increase in capability; improved passenger capacity is 100 percent for those vehicles that can carry a full nine-member squad and zero for other vehicles. See the appendix for details concerning CBO's metrics.
- e. Based on the December 2010 version—the Design Concept After Trades—of the GCV after additional design trade-offs that the Army made to reduce the average procurement unit cost to \$13.5 million (in 2013 dollars).

IFV fleet could be maintained through 2030. The Army could continue to investigate ways to improve the current Bradleys, but it would not field any new or improved vehicles.

secondary metric emphasized a vehicle's ability to achieve the Army's goals by giving more weight to its capacity for carrying passengers and by giving additional credit to vehicles that can carry a nine-member squad.

**How Were Differences Assessed?**

To estimate the improvement in capability the GCV and the alternative vehicles would yield compared with the current Bradley IFV, CBO applied two metrics based on characteristics that are considered important in a fighting vehicle. Those measures combined the various improvements the alternative vehicles offer in four categories compared with the current Bradley IFV: protection of soldiers and survivability of the vehicle in combat; lethality; mobility to and around the battlefield; and passenger capacity.

CBO's primary metric weighed improvements in each category on the basis of soldiers' preferences. The agency's

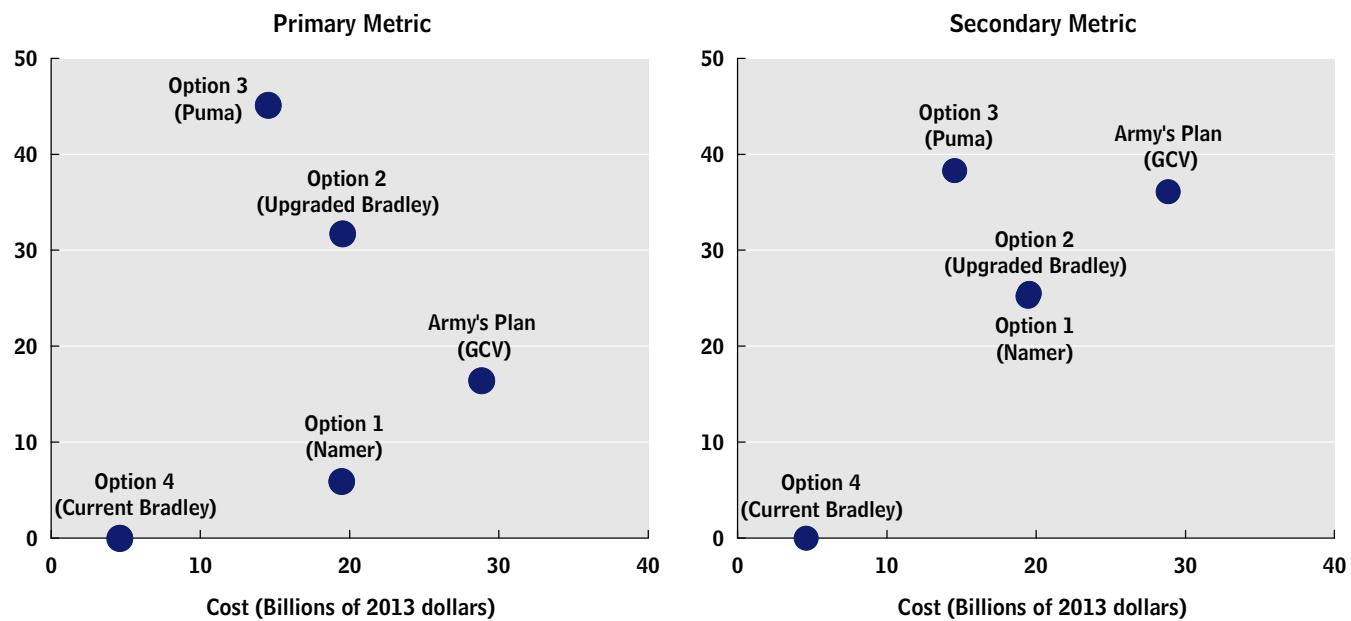
**Which Vehicles Would Be Most Capable?**

On the basis of CBO's primary metric, the Puma would be the most capable of the vehicles, and both it and the upgraded Bradley IFV would be significantly more capable than the GCV (see Summary Table 2 and Summary Figure 1). In addition, fielding Pumas or upgraded Bradleys would cost \$14 billion and \$9 billion less, respectively, than the Army's program for the GCV and would pose less risk of cost overruns and schedule delays. Although the Namer would be much less capable than the GCV overall, it would still provide the Army with a vehicle that could carry nine passengers, and

### Summary Figure 1.

## Cost and Improvement in Capability Under the Army's Plan and CBO's Options, Using Two Metrics

(Percentage improvement relative to the current Bradley IFV)



Source: Congressional Budget Office.

Notes: The Army's plan would field the GCV, Option 1 would purchase the Israeli Namer APC, Option 2 would upgrade the Bradley IFV, Option 3 would purchase the German Puma IFV, and Option 4 would retain the current Bradley IFV.

For the GCV program and Options 1 and 2, the total cost covers development and purchase of 1,748 vehicles. For Option 3, the total cost covers development and purchase of 2,048 vehicles. For Option 4, the cost is the amount needed to extend the life of the Army's current Bradley IFVs and to continue research and development.

For CBO's primary metric, the overall improvement in capability is based on the weighting (derived from the Army's analysis) of improvements in four areas: protection and survivability (40 percent), lethality (30 percent), mobility (20 percent), and maximum number of passengers (10 percent). For CBO's secondary metric, improvements in the same four areas are weighted equally to determine an overall increase in capability; improved passenger capacity is 100 percent for those vehicles that can carry a full nine-member squad and zero for other vehicles. See the appendix for details concerning CBO's metrics.

IFV = infantry fighting vehicle; GCV = Ground Combat Vehicle; APC = armored personnel carrier.

fielding it would cost \$9 billion less than the Army's plan for fielding the GCV.

The Puma is slightly more capable than the GCV, but the upgraded Bradley IFV and the Namer are less capable than the GCV in an evaluation of the various vehicles on the basis of CBO's secondary metric, which emphasizes the ability to carry a nine-member squad. Because the GCV and the Namer are the only vehicles CBO studied that could carry a full nine-member squad, their capability is higher relative to the other vehicles by that metric. As a result, the GCV is nearly comparable to the Puma, and the Namer is equal to the upgraded Bradley, although less capable than either the GCV or the Puma. Even by CBO's secondary metric, fielding a fleet of

Pumas would give the Army slightly more capability than a fleet of GCVs and at only half the cost of the GCV. The Puma fleet also would pose a lower risk of cost overruns or schedule delays.

No improvement over the fleet's current capability would be achieved if the Army canceled the GCV program and instead decided to rely on the current Bradley IFVs until the need for additional capabilities became more pressing and new technologies were readily available. Nevertheless, that approach offers other advantages: The cost to the Army would be \$24 billion less than the projected cost of the GCV program, and the service would incur essentially no programmatic risk.

# The Army's Ground Combat Vehicle Program

**T**he Army's Ground Combat Vehicle (GCV) program is part of its plan to modernize its fleet of combat vehicles. Although the service's plan includes modernizing all existing combat vehicles by replacing or upgrading them, the first priority is to develop and field a new "highly survivable" infantry fighting vehicle (IFV) that can transport a full nine-member squad of soldiers (along with the vehicle's crew) to, from, and around a battlefield. The GCV is the Army's first new combat vehicle designed to better withstand the effects of improvised explosive devices (IEDs) that have been employed with such devastating effects in Iraq and Afghanistan.

This analysis by the Congressional Budget Office (CBO) of the GCV program and possible alternatives is based solely on the Army's goals and plans for that vehicle. As a starting point, CBO accepted the Army's goals for the new IFV program—specifically, those for the vehicle's performance and for the number of vehicles it estimates are needed to equip and support its forces. CBO then assessed the ability of the GCV and the other vehicles to meet those goals, determined the improvement in capabilities the vehicles would provide relative to the capabilities of the Bradley Infantry Fighting Vehicle (the Army's current IFV), and estimated the cost of developing and purchasing the number of those vehicles needed to equip and support its forces on the same schedule.

Using the Army's goals for the GCV program necessarily limited the scope of CBO's analysis. Different goals for a new IFV would have changed the criteria that CBO used to evaluate the GCV program and the various alternatives. For example, answers to questions about the threats the Army will face in the future and how its armored forces will confront those threats would affect which capabilities the service would emphasize in its new vehicle and the number of vehicles it would need to equip its forces. Also outside the scope of this analysis were considerations of how the choice of a particular contractor, or

team of contractors, to design and produce the GCV might affect the U.S. industrial base or employment.

## The Army's Rationale and Goals for a New Infantry Fighting Vehicle

For almost a decade, the Army has been planning to develop and field new combat vehicles, but the decision to field a new IFV along the lines of the GCV has arisen primarily from experience in Iraq.<sup>1</sup> During the earliest years of Operation Iraqi Freedom, dozens of Bradley IFVs were destroyed or damaged by mines and IEDs and, in some cases, their occupants killed or injured. The Army subsequently improved the Bradley IFV by bolting on more armor and adding electronic equipment to prevent remotely controlled IEDs and mines from exploding and damaging the vehicle or injuring the troops it carried. But the Bradley was designed in the 1970s and has been upgraded repeatedly over the past 30 years; the additional weight and demands for electrical power associated with the improvements have strained the vehicle's capacity.

To remedy the shortcomings of the current Bradley IFV—its vulnerability to damage from IEDs and mines, its overburdened suspension and electrical system, and its lack of capacity for more and newer equipment—the Army has decided to field an entirely new infantry fighting vehicle that is better suited to the modern battlefield. According to the Army, one lesson from operations in Iraq is that the service "needs a Ground Combat Vehicle

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1. The GCV program is in some ways a continuation of the Future Combat Systems program, which was canceled in 2009 by the Secretary of Defense. That program would have developed and fielded new combat vehicles to replace all of the Abrams tanks, Bradley fighting vehicles, self-propelled howitzers, and M113-based vehicles in an armored combat brigade. For more details on the Future Combat Systems program, see Congressional Budget Office, *An Analysis of the Army's Transformation Programs and Possible Alternatives* (June 2009), [www.cbo.gov/publication/41186](http://www.cbo.gov/publication/41186).

**Box 1-1.****The Army's Emphasis on Transporting Full Nine-Member Squads**

The infantry fighting vehicle (IFV) is both the primary weapon and a means of transport for soldiers in the mechanized infantry squads that the Army considers essential to its future operations. As currently configured, each mechanized infantry platoon is staffed with a platoon leader, three squads of nine soldiers, and a three-member crew for each of the platoon's four Bradley Infantry Fighting Vehicles. Because the current Bradley can carry at most seven people in addition to the crew, squads must be divided among vehicles.<sup>1</sup> The Army sees that inability to carry a full nine-member squad as a liability because of difficulties with organization and communications that can ensue immediately after soldiers exit a vehicle, especially if the vehicle is under fire or operating in a complex environment, such as a city.

A lack of space for additional passengers is a drawback for a platoon as well. Between them, a platoon's four Bradley IFVs can carry a total of 28 passengers,

1. For more details, see Bernard Kempinski and Christopher Murphy, *Technical Challenges of the U.S. Army's Ground Combat Vehicle Program*, Working Paper 2012-15 (Congressional Budget Office, November 2012), pp. 3–5, [www.cbo.gov/publication/43699](http://www.cbo.gov/publication/43699).

in addition to crew members, thus accounting for squad members and the platoon leader but no one else. Yet additional soldiers often are needed to accompany mechanized infantry platoons during operations, and it is to the platoon's advantage to have those supporting soldiers ride along in a platoon vehicle. For example, radio-telephone operators, medics, and forward observers (who call for supporting fire from artillery and aircraft) typically accompany soldiers in a platoon. The four Bradley IFVs assigned to each platoon have no room to accommodate such personnel.

The Army is seeking to remedy that deficiency by replacing the Bradley IFV with the larger Ground Combat Vehicle (GCV), which would carry a full nine-member squad in addition to its three-member crew. The Army plans to replace its current fleet of Bradley IFVs with an equal number of GCVs. A platoon equipped with four GCVs could carry each of three squads in separate vehicles, leaving the fourth vehicle available to transport the platoon leader, supporting personnel (such as forward observers and medics), and any additional personnel needed.

that incorporates protection against improvised explosive devices, tactical mobility, and operational agility.”<sup>2</sup> The Army also wants a vehicle that can accommodate additional equipment so that the service can easily modify the vehicle as the operational environment changes and new technology becomes available. Another key goal is the capacity to transport a nine-member infantry squad on the battlefield—something that the current Bradley IFV,

which has room for only seven soldiers in addition to its crew, cannot do.<sup>3</sup> The Army's rationale is that keeping the squad together in one vehicle will improve the effectiveness of the squad when soldiers first exit the vehicle, which is central to success in combat (see Box 1-1).<sup>4</sup>

**Schedule, Fielding, and Cost of the GCV Program**

The Army wants to field the first GCVs in what would be an unusually short time for such a complicated new system. Technology development began in December

2. See Department of the Army, Capabilities Integration Center, *The Squad and Its Ground Combat Vehicle* (2011), <http://go.usa.gov/4fDJ>. CBO has examined the Army's goals for the GCV as well as how mines, IEDs, and antitank weapons work and technical approaches (including advanced armor) to counter those weapons. See Bernard Kempinski and Christopher Murphy, *Technical Challenges of the U.S. Army's Ground Combat Vehicle Program*, Working Paper 2012-15 (Congressional Budget Office, November 2012), [www.cbo.gov/publication/43699](http://www.cbo.gov/publication/43699).

3. Army documents disagree about the number of fully equipped soldiers that can be transported in a Bradley IFV. Most sources indicate that the vehicle can carry seven soldiers, but only under cramped conditions.

4. Department of the Army, Capabilities Integration Center, *The Squad and Its Ground Combat Vehicle* (2011), <http://go.usa.gov/4fDJ>.

2011 and will continue through June 2014.<sup>5</sup> Then, more than four years of engineering and manufacturing development will take place. Production is scheduled to begin in 2019, and the first production vehicle could be available in 2020.<sup>6</sup>

The GCV is slated as a replacement for the Army's Bradley IFV in armored combat brigades. At the end of 2012, the active component of the Army and the National Guard together included 24 armored combat brigades, although that number is likely to be reduced by at least two as the Army trims its forces over the next several years. On the basis of information supplied by the Army, CBO estimates that the Army will require 1,748 GCVs to equip 22 armored combat brigades—each assigned 61 GCVs and 2 spare vehicles—and to provide additional vehicles for use in training and support activities and in prepositioned sets of equipment.<sup>7</sup> According to the current schedule, vehicle purchases will begin in 2019. On the basis of the Army's planning documents, CBO assumes that purchases will reach an annual rate of 156 by 2021 and that procurement would extend through 2030.

In preparation for beginning the first stage of development—a step known as Milestone A—the Army generated a preliminary design and cost estimates for development and procurement.<sup>8</sup> On the basis of those preliminary estimates, and as revised to reflect changes made in the program in January 2013, CBO projects a total development cost of \$5.3 billion for the period from

5. Based on the schedule directed by Frank Kendall, Undersecretary of Defense for Acquisition, Technology, and Logistics, in an acquisition decision memorandum to the Secretary of the Army, January 16, 2013.
6. The original Army schedule was shorter than the current one. Contracts signed in August 2011 with two companies that were to perform technology development were delayed by a protest until December 2011 (the first quarter of fiscal year 2012). That original schedule called for two years of technology development, starting in 2012, followed by four years of engineering and manufacturing development, starting in early 2014. Thus, production of the GCV would have begun in 2018, and the Army would have accepted the first production vehicle in 2019, seven years after technology development began.
7. Specifically, 15 vehicles for testing before full production begins, 1,386 to equip 22 armored combat brigades, 189 to equip three brigade sets stored aboard ships or overseas for contingencies, 120 for training, and 38 for the Army National Guard. Reducing the number of armored combat brigades to fewer than 22 would reduce the number of GCVs the Army would need to purchase.

2014 through 2021. Because the program is still in the early stages, it is difficult to project procurement costs accurately. However, in August 2011, when approving the program's entry into technology development, the Undersecretary of Defense for Acquisition, Technology, and Logistics established an upper limit of \$13.5 million for the average cost to purchase a vehicle.<sup>9</sup> Using that ceiling as a basis, CBO estimated that the cost of purchasing 1,748 GCVs would be \$23.5 billion and that the total cost of development and procurement for the program would be \$28.8 billion from 2014 through 2030.

### Capability of the GCV

Because it is still in the early stages of development, the GCV's characteristics are still in flux. In August 2011, two teams were placed under contract to begin development, and they were given considerable flexibility in meeting the Army's goals. One contractor, for example, has proposed using a conventional diesel engine for the vehicle; the other proposes a hybrid electric engine. Although the Army's goals themselves are subject to change at any time during development, the average procurement cost of the vehicle cannot exceed the cap. Thus, any extra cost from increasing capability in one area must be offset by savings in some other area. What trade-offs will be made, however, will not be known until development is complete and the vehicle goes into production.

CBO conducted its analysis on the version of the GCV—known as the GCV Design Concept After Trades, but here referred to as the notional GCV—that the Army proposed before beginning technology development in August 2011. The cost, characteristics, and performance of that notional version are well documented and were described in a report the Army delivered to the Congress in March 2011.<sup>10</sup> That notional version had already made

8. Official estimates of the costs of major acquisition programs are typically not published by the Office of the Secretary of Defense until a program has entered into engineering and manufacturing development. The GCV program is not scheduled to enter that phase until June 2014.
9. That amount (known as the average procurement unit cost) is the procurement cost of all GCVs divided by the total of 1,748 to be purchased. An average cost of \$13 million in 2011 dollars is equal to \$13.5 million in 2013 dollars.
10. Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives*, Tab B, "Ground Combat Vehicle Trade Impact Analysis" (March 2011).

**Table 1-1.****Characteristics of the Current Bradley IFV and the GCV**

	Current Bradley IFV <sup>a</sup>	GCV <sup>b</sup>
	Number of Occupants	
Crew	3	3
Passengers	7 <sup>c</sup>	9
<b>Physical Characteristics</b>		
Weight (Tons) <sup>d</sup>	33 to 39	50 to 65
Dimensions (Feet)		
Length	23	28
Width	12.8	13.7
Height	10.6	13.7
Engine Capacity (Horsepower)	600	1,500
<b>Armament</b>		
Cannon (Caliber in mm)	25	25
Antitank Missile	TOW	n.a.
Machine Gun (Caliber in mm)		
RCWS	n.a.	12.7
Coaxial	7.62	7.62

Source: Congressional Budget Office based on Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives* (March 2011), and other sources.

Note: IFV = infantry fighting vehicle; GCV = Ground Combat Vehicle; mm = millimeters; TOW = tube-launched, optically tracked, wire-guided; RCWS = remotely controlled weapon station; n.a. = not applicable.

- a. Version of the M2A3 Bradley IFV used in Iraq, which includes reactive armor and underbelly armor.
- b. Based on the December 2010 version—the Design Concept After Trades—of the GCV after additional design trade-offs that the Army made to reduce the average procurement unit cost to \$13.5 million (in 2013 dollars).
- c. Army documents disagree about the number of fully equipped soldiers that can be transported in a Bradley IFV. Most sources indicate that the vehicle can carry seven soldiers, but only under cramped conditions.
- d. The lower end of the range represents the weight of the vehicle without added armor or other protective measures. The upper end of the range includes the weight of currently proposed protective equipment that could be or has been added to the vehicle.

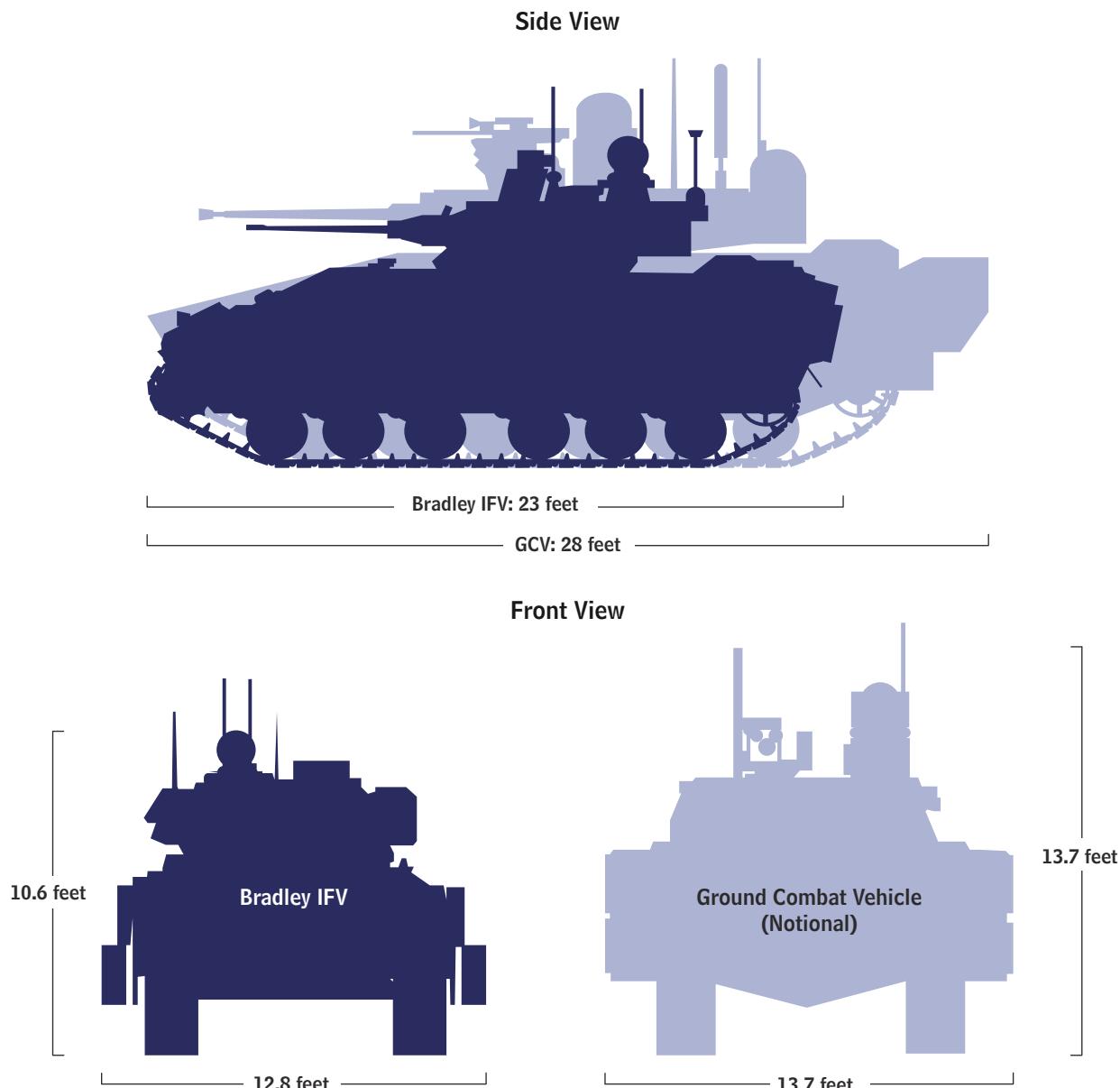
compromises between various subsystems, such as cannon size, type and amount of armor, and the inclusion of antitank missile launchers, to reduce the cost to an amount that the Army considered affordable. All discussions of the characteristics of the GCV in this report refer to the notional GCV. (The Army intends to change the requirements for the amount of protection and the size of the GCV's cannon. CBO's analysis could not account for those changes because the details are still pending.)

**Description of the GCV**

The Army envisions the GCV as providing protection for soldiers as they are transported to, from, and around the battlefield and, if necessary, also engaging and destroying enemy vehicles and personnel. The GCV would replace the infantry version of the Bradley fighting vehicle within the Army's armored combat brigades, but it would be larger and able to carry more soldiers into battle—nine compared with the Bradley's seven. It also would be designed with enough interior space to accommodate new equipment as it becomes available (see Table 1-1 and Figure 1-1). In addition, because of the Army's stringent goals for soldiers' protection, the GCV is to be heavily armored; as a consequence, the notional vehicle weighs 65 tons when fully protected and equipped with the most effective modular armor. At that weight, the vehicle would be 67 percent heavier than the current Bradley IFV, which weighs 39 tons even when equipped with the additional armor needed for operations in Iraq. The GCV is likely to have a turret equipped with a cannon—the Army's notional version includes a 25 millimeter (mm) cannon similar to that on the current Bradley IFV—and two additional machine guns and various sensors to detect enemy forces.<sup>11</sup> In order to meet the Army's goals for off-road travel, the GCV will be equipped with tracks rather than wheels.

The GCV program also includes the development of armor kits to protect against direct-fire weapons (rifles, machine guns, and cannons), antitank weapons, mines, and IEDs. Various kits would be designed to meet differing levels of threat (for example, medium-sized mines at one level versus large antitank mines at another). The lowest level of protection, from direct-fire rounds and mines, would be provided by armor built into the vehicle's hull and chassis. Kits, known as modular armor, for

11. In January 2013, the service revised its goals for the vehicle's cannon to specify a caliber of 30 mm or larger. The goal established at the beginning of technology development stipulated a minimum caliber of 25 mm.

**Figure 1-1.****Dimensions of the Current Bradley IFV and the GCV**

Source: Congressional Budget Office based on Army data.

Notes: GCV dimensions are based on the December 2010 version—the Design Concept After Trades—of the GCV after additional design trade-offs that the Army made to reduce the average procurement unit cost to \$13.5 million (in 2013 dollars), as described in Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives* (March 2011).

IFV = infantry fighting vehicle; GCV = Ground Combat Vehicle.

the other levels of protection would be added as needed for specific operations. In that way, a vehicle need not carry the added weight if greater protection is not required.

### Improvements in Capability

The GCV would be more capable than the current Bradley IFV in some respects but potentially less so in others. The Army requires that the GCV carry two more soldiers than the current Bradley IFV can accommodate, and the engine must be more powerful because the vehicle will be heavier and larger than the current Bradley. The bottom of the GCV will clear the ground by at least 7 inches more than the current IFV does, thereby reducing its vulnerability to mines. Although the notional GCV was equipped with a cannon of the same caliber as that on the current Bradley, the vehicle did not have an antitank missile launcher and so would be less effective against enemy armored vehicles.

CBO compared the capabilities of the notional version of the GCV with those of the current Bradley IFV in four areas. Specifically, the Army has established goals for improvement in protection of occupants of the vehicle and survivability (defined as the ability of the vehicle to withstand attacks and still continue to operate), lethality (the ability to destroy enemy forces), mobility (the ability to travel on- and off-road), and passenger capacity. As a basis for comparison, CBO used data and results from the Army's analysis of the performance of the GCV and the Bradley IFV in those four categories.

**Protection and Survivability.** The GCV would provide better protection for soldiers and would operate longer on the battlefield than the current Bradley IFV, according to analyses that the Army conducted from February through December 2010. In a series of computer simulations of combat, the Army replaced the current Bradley IFV with the notional GCV.<sup>12</sup> Units equipped with the GCV lost almost 30 percent fewer occupants—crew and passengers—than did units equipped with current Bradley IFVs. The largest relative improvement—60 percent fewer losses—occurred in simulations in which U.S. forces confronted unconventional threats and small numbers of combatants, situations that were similar to

12. The Army simulated combat under several scenarios, including incidents in Iraq and Afghanistan that employed company-sized U.S. forces, a battalion-sized encounter in southwest Asia, and a brigade-sized battle in northeast Asia.

recent operations in Iraq and Afghanistan. Smaller reductions were seen in the number of soldiers lost in scenarios that featured larger, more conventional battles against enemies equipped with armored vehicles.

The GCVs themselves proved better at surviving an attack than current Bradleys. On average, across all scenarios, 22 percent fewer GCVs were lost (a vehicle is considered lost if it is damaged beyond the ability to operate); in one scenario, roughly 40 percent fewer GCVs were lost. (However, in the simulation of the most intense battle—set in northeast Asia—the GCVs' survivability was no greater than that of the current Bradley IFVs.) The overall improvement was 27 percent in protection for soldiers and survivability of the GCVs compared with the current Bradley IFVs (see Table 1-2).<sup>13</sup>

**Lethality.** The GCVs destroyed fewer enemy forces (that is, enemy vehicles and personnel) than did the current Bradley IFVs in the Army's combat simulations. Specifically, on average across all scenarios, the notional GCVs were 7 percent less lethal against enemy forces than were the current Bradley IFVs.<sup>14</sup> If the enemy was equipped with armored vehicles, GCVs destroyed fewer enemy vehicles than did the current Bradleys because GCVs lack the Bradleys' antitank missiles. However, GCVs destroyed more enemy personnel in the simulations because the vehicles survived longer and were equipped with an additional machine gun and with better sensors for finding and identifying targets.

**Mobility and Passenger Capacity.** The GCV would be more mobile and carry more passengers than the current Bradley IFV. Plans for the new vehicle indicate that the GCV will accelerate faster, attain higher off-road speeds, and go farther on a tank of fuel. Despite its larger size and weight, the notional GCV's increased speed and acceleration yielded a 24 percent overall improvement in mobility. In addition, the GCV would accommodate two

13. The assessment of the overall increase in protection and survivability was based on a 67/33 weighting of the increase in the number of soldiers protected relative to the increase in the number of vehicles that survived in the Army's simulations.

14. The overall increase or decrease in effectiveness against enemy forces was based on a 60/40 weighting of the number of enemy vehicles destroyed relative to the number of enemy personnel killed. Those weights are based on responses from Army personnel to surveys regarding which attributes of combat vehicles are most important to soldiers. See the appendix for more details.

**Table 1-2.****Improvement of the GCV Compared with the Current Bradley IFV**

	Improvement in Capability (Percent)
Protection and Survivability <sup>a</sup>	27
Lethality <sup>b</sup>	-7
Mobility <sup>c</sup>	24
Passenger Capacity	
Increased number of passengers	29
Ability to carry a full nine-member squad	100
Overall Improvement Relative to the Current Bradley IFV	
Primary metric <sup>d</sup>	16
Secondary metric <sup>e</sup>	36

Sources: Congressional Budget Office based on Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives* (March 2011); and Department of the Army, personal communication to CBO staff, May 2012.

Notes: The GCV is the notional version, based on the December 2010 Design Concept After Trades, which includes additional design trade-offs that the Army made to reduce the average procurement unit cost to \$13.5 million (in 2013 dollars).

GCV = Ground Combat Vehicle; IFV = infantry fighting vehicle.

- a. Protection is the vehicle's ability to protect its occupants from effects of attacks. Survivability is the vehicle's ability to withstand attacks and still continue to operate. Improvement is determined by the reduction in losses of vehicles and personnel.
- b. Lethality is the vehicle's ability to destroy enemy personnel and vehicles.
- c. Mobility is the ability to travel on- and off-road.
- d. CBO's primary metric determines the overall improvement in capability based on the weighting (derived from the Army's analysis) of improvements in four areas: protection and survivability (40 percent), lethality (30 percent), mobility (20 percent), and maximum number of passengers (10 percent). See the appendix for details concerning CBO's metrics.
- e. CBO's secondary metric gives equal weight to the improvement in each of the four areas in order to determine an overall increase in capability; improved passenger capacity is 100 percent for those vehicles that can carry a full nine-member squad and zero for other vehicles. See the appendix for details concerning CBO's metrics.

more passengers than the current Bradley IFV, for a capacity increase of 29 percent. Because of that larger capacity, the GCV also would be able to transport a full nine-member infantry squad, thus meeting one of the Army's main goals for the program.

**Overall Improvement.** CBO used two metrics to gauge the notional GCV's overall improvement in capability relative to that of the current Bradley IFV (see the appendix). Both metrics combined the GCV's improved (or reduced) capabilities—in protection and survivability, lethality, mobility, and passenger capacity—to yield a comprehensive measure of overall improvement. And both used results from the Army's combat simulations involving the current Bradley IFV and the notional GCV to measure changes in protection, survivability, and lethality. Also common to both metrics was an evaluation of the mobility of the two vehicles, based on such

automotive characteristics as the rate of acceleration, maximum off-road speed, turning radius, and range of operation on a single tank of fuel. The fourth area—passenger capacity—was evaluated in two ways: CBO's primary metric considered the percentage increase in the number of passengers carried beyond the seven carried by the current Bradley IFV, and its secondary metric took into account whether a vehicle could carry a full nine-member squad. (If a vehicle could carry a full squad, it was considered to provide a 100 percent increase in capability; if it could not, the percentage increase was deemed to be zero.)

CBO combined the increase—or decrease—in capability attributed to the GCV in those four areas by using different weighting schemes for the two metrics. The primary metric used a weighting scheme derived from the one used by the Army in its analysis of alternatives

before the entry of the GCV program into technology development.<sup>15</sup> That scheme—based on soldiers' preferences—places more emphasis on improvements in protection and survivability, lethality, and mobility than on greater passenger capacity.<sup>16</sup> The secondary metric, in contrast, is designed to emphasize the GCV's ability to meet all of the Army's goals for its new IFV. It gives equal weight to improvements in each of the four areas, thereby allotting improvement in passenger capacity a weight of 25 percent rather than 10 percent as in the primary metric. In addition, the secondary metric gives additional credit to those vehicles that can carry a nine-member squad.

CBO's primary metric indicates that the notional GCV would yield an overall improvement in capability of 16 percent; CBO's secondary metric—which favors vehicles that can carry nine soldiers—suggests that the GCV would represent a 36 percent improvement in capability (see Table 1-2 on page 11). The notional GCV also would offer advantages over the current Bradley IFV in communications, future adaptability, and maintenance. For example, it would be equipped with the Army's latest communications and networking equipment and therefore could more easily maintain contact with other Army forces. In addition, the GCV would be better able to accommodate the added weight and increased demand for electrical power typically associated with future improvements of such vehicles. In its assessments, the Army has concluded that the GCV also would be easier to maintain than the current Bradley IFV.

## Concerns About the GCV Program

Defense analysts and policymakers have questioned several aspects of the GCV program, including its far-reaching objectives, its ambitious schedule, its applicability in the current defense environment and in the likely environment of the future, and its combination of limited scope and significant cost.

15. Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives*, Tab I, "Ground Combat Vehicle Affordability Strategy" (March 2011). See the appendix for a description of the Army's and CBO's weighting schemes.

16. The primary metric assigns weights to improvements in the four areas: protection and survivability (40 percent), lethality (30 percent), mobility (20 percent), and passenger capacity (10 percent). See the appendix for more details.

## Challenges in Meeting Goals, Cost Constraints, and Schedule

The GCV program faces several obstacles to meeting the Army's main goals for the GCV—protecting occupants against land mines and IEDs, carrying a nine-member squad, and operating in all possible future conflicts—within the prescribed cost per vehicle and the current schedule. Trade-offs will probably be necessary.

**Technical Challenges.** The GCV program must overcome several technical obstacles before the vehicle goes into production if it is to meet the Army's goals. One set of challenges involves the vehicle's ability to generate and store enough electrical power—many times that required for the Army's current vehicles—to supply the systems that the GCV is likely to include over its lifetime. Other challenges involve protecting the vehicle's occupants without increasing its weight beyond the capacity of the planned automotive system. Ceramic and other types of effective lightweight armor currently exist, but the materials are either very costly to manufacture or will require several more years in development for use on a vehicle like the GCV. Alternatively, the Army could rely on an active protection system that uses vehicle-mounted sensors to detect incoming rounds or missiles and then launches missiles or munitions to destroy or deflect them. Most active protection systems, however, have not yet proved reliable in countering incoming rounds under typical battlefield conditions.<sup>17</sup> Without an effective system for the new vehicle, its developers may need to add even more armor to achieve the Army's goals for protecting personnel and equipment.

## Challenges in Containing Costs and Meeting Schedules

An added difficulty concerns meeting technical challenges while still keeping to target costs and schedules. In fact, technical challenges and cost constraints have already forced the Army to make trade-offs among capabilities. In establishing its goals for the GCV before entering technology development, the Army had to give up an antitank missile launcher—similar to one on the current Bradley IFV—that could have been mounted on the GCV's turret. It also elected to forgo armor kits that would provide additional protection for two-thirds of the planned vehicles, and it chose a 25 mm cannon rather

17. Many such challenges are discussed more fully in Bernard Kempinski and Christopher Murphy, *Technical Challenges of the U.S. Army's Ground Combat Vehicle Program*, Working Paper 2012-15 (Congressional Budget Office, November 2012), [www.cbo.gov/publication/43699](http://www.cbo.gov/publication/43699).

than the larger 30 mm cannon originally specified. In addition, the sensors and optics on the notional vehicle are less sophisticated than those the Army had originally hoped to include.

Even so, questions regarding the cost of the Army's preliminary design were raised when the Army sought approval for the program's entry into technology development. The Office of the Director of Cost Assessment and Program Evaluation (CAPE) in the Office of the Secretary of Defense estimated that the average per-unit procurement cost for the notional version of the GCV that was approved in August 2011 was \$4 million more than the cost the Army had estimated for the vehicle. Nevertheless, when the Undersecretary authorized the GCV program's entry into technology development in August 2011, the Army's estimate of \$13.5 million was accepted as the baseline cost.<sup>18</sup>

Concerns about the program's affordability and feasibility may have contributed to the Army's being assigned several tasks as a prerequisite to the GCV program's entering the second stage of development, and they certainly contributed to the Army's revision of its goals for the program in January 2013. When the Undersecretary approved the entry of the GCV program into technology development in August 2011, he directed the Army to continue to evaluate possible alternatives before entering the next phase.<sup>19</sup> Specifically, the Army was directed to update the analysis of alternatives it had conducted before August 2011 and to explore trade-offs between specific capabilities and costs. As a result of those assessments, in January 2013 the Army revised its requirements in order to achieve a more affordable and technically feasible design.<sup>20</sup> Those revisions include a reduction in the Army's goals for protection (which makes the need for an

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18. At the same time, the Undersecretary required a review of the cost estimate before the program could enter the next phase (engineering and manufacturing development)—now scheduled for June 2014—and CAPE was directed to assess whether the trade-offs that the Army makes during technology development would be sufficient to keep the vehicle's unit cost below the cap.
19. The Army was also directed to support its findings with assessments of existing combat vehicles to determine whether they were adequate alternatives to a new vehicle or whether some of the designs or capabilities of existing vehicles should be incorporated into a new GCV. The results of studies by the GCV contractor teams (concerning technology demonstrations and trade-offs between various capabilities and their costs) during the technology development phase were to be considered in the updated analysis of alternatives as well.

effective active protection system unlikely) and an increase in the goals for lethality (which will require a cannon with a caliber of 30 mm or greater).

Inasmuch as the program was only slightly more than a year old when the equipment requirements were changed, it is likely that additional trade-offs will be necessary as the Army learns more about the technical feasibility and cost of meeting its goals. Cost estimates produced during the early stages of weapons programs generally are revised upward as work progresses: Historically, actual costs have averaged about 50 percent higher than the costs projected at the time a system enters the technology development phase.<sup>21</sup> In particular, if CAPE's cost estimate proves to be more accurate than the Army's, or if the costs of some subsystems rise unexpectedly, further trade-offs will be necessary to prevent procurement costs from exceeding the cap.<sup>22</sup>

The GCV program's ambitious schedule and technical challenges also create concern. The schedule established in August 2011, which would have begun production in 2018, was particularly ambitious. Representatives of the Government Accountability Office highlighted the risk inherent in that schedule in testimony in October 2011, noting that the Army faced a major difficulty in its attempts to deliver a feasible, cost-effective GCV program that could be carried out according to the Army's schedule.<sup>23</sup> That challenge was acknowledged when the Undersecretary of Defense for Acquisition, Technology, and Logistics directed the Army in January 2013 to extend the technology development phase of the program by six months to allow additional time to react to the

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20. Frank Kendall, Undersecretary of Defense for Acquisition, Technology, and Logistics, informational memorandum to the Deputy Secretary of Defense, January 16, 2013.
21. Mark V. Arena and others, *Historical Cost Growth of Completed Weapon System Programs*, TR-343 (RAND Corporation, 2006), [www.rand.org/pubs/technical\\_reports/TR343.html](http://www.rand.org/pubs/technical_reports/TR343.html).
22. CAPE's estimate of the cost of the GCV program could be more accurate than the Army's estimate, but CBO chose to use the Army's figures in large part because CAPE had no cost estimates for development or purchase of alternative vehicles. (See Chapter 2 for a discussion of the various programs' costs.)
23. Answers for the record, by Belva M. Martin, Director, Acquisition and Sourcing Management, Government Accountability Office, submitted subsequent to the hearing on Army Acquisition and Modernization Programs before the Subcommittee on Tactical Air and Land Forces of the House Committee on Armed Services (October 26, 2011), <http://go.usa.gov/4cWV>.

Army's revised requirements.<sup>24</sup> The Army also was directed to extend the second phase of the program—engineering and manufacturing development—with the result that 2019 is the earliest that production may begin.

### Role in Future Conflicts

What role the GCV will have and what its utility in future conflicts is likely to be are unclear now, in part because U.S. military strategy has changed but also because the vehicle would be so large and heavy. The current Administration's strategy emphasizes protecting U.S. interests in Asia and the Pacific Rim and deploying armed forces that can respond rapidly to threats. Some analysts assert that the new strategy would make the use of large numbers of armored Army forces less likely in the future than it has been in the past. The other services—the Air Force, Navy, and Marine Corps—already have a large, dispersed presence in the Pacific region that is likely to increase in the next few years.<sup>25</sup> Furthermore, it would take at least three weeks to move even a single armored combat brigade—equipped with 61 GCVs—from the United States to the site of a conflict in Asia, for example.

Questions about the sorts of threats that the Army will face in future combat combine to create another area of uncertainty. If large numbers of the Army's armored forces were involved in a large-scale conflict with an armored foe, the combat vehicles used by U.S. forces might not need the amount of protection from all possible threats that the GCV aims to provide.<sup>26</sup> In the past, the most damaging attacks on individual armored vehicles in combat have come from the front (from enemy

24. Frank Kendall, Undersecretary of Defense for Acquisition, Technology, and Logistics, acquisition decision memorandum to the Secretary of the Army, January 16, 2013.

25. Testimony of Robert M. Scher, Deputy Assistant Secretary of Defense for Plans, and David F. Helvey, Acting Deputy Assistant Secretary of Defense for East Asia, before the Readiness Subcommittee of the House Committee on Armed Services, *U.S. Posture in the U.S. Pacific Command Area of Responsibility* (August 1, 2012).

26. For a discussion of armor needs in different types of conflicts, see Bernard Kempinski and Christopher Murphy, *Technical Challenges of the U.S. Army's Ground Combat Vehicle Program*, Working Paper 2012-15 (Congressional Budget Office, November 2012), [www.cbo.gov/publication/43699](http://www.cbo.gov/publication/43699).

tanks and antitank missiles). For that reason, vehicles designed for use in battles envisioned during the Cold War had well-protected fronts, with less protection on the sides and top and very little at the back or on the bottom. If this is the type of threat that the GCV is likely to face in the future, then it may be overprotected.

If future engagements are similar to those in Iraq and Afghanistan, the value of the GCV's additional armor might be diminished by the fact that its size and weight could limit its usefulness. Similar vehicles—the Army's Bradley IFVs and Abrams tanks—were not used extensively in cities in Iraq and not used at all in Afghanistan. And statements by Army leaders in 2010, notably by then-Army Chief of Staff General George Casey, indicated the belief that the GCV should be much smaller and lighter than currently planned. According to reports in the press, General Casey said that "soldiers who have served in Iraq and Afghanistan have told [me] that big, heavy vehicles just aren't practical in urban combat" and that the Army "stopped using tanks and Bradleys on the streets of Baghdad just because of the size."<sup>27</sup> Moreover, large vehicles can be too heavy for many countries' roads and bridges, leading one expert to suggest that "an optimal weight for a vehicle in an irregular warfare environment is 40 to 45 tons"—significantly less than the 65 tons that the fully protected notional GCV was estimated to weigh.<sup>28</sup>

### Program Scope and Affordability

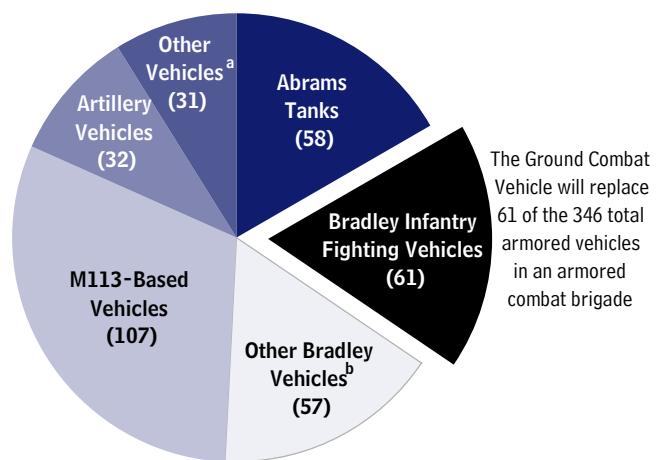
The GCV program is the Army's first priority, the service asserts, as it attempts to modernize its ground combat fleet. In answers for the record after testimony in October 2011, Lieutenant General Robert Lennox, who at the time was the Army's Deputy Chief of Staff for financial management, stated that the GCV is among the Army's most important programs because it will allow "an infantry squad to accompany tanks in both open and complex terrain, from initial contact to the objective" and that "the GCV will fill capability gaps that currently exist in

27. Matthew Cox, "U.S. Army Chief of Staff Wants Lighter GCV," *Defense News* (June 20, 2010).

28. Sydney J. Freedberg Jr., "Army Tries Again for a New Tank," *National Journal* (August 7, 2010).

**Figure 1-2.****Distribution of Armored Vehicles in an Armored Combat Brigade**

(Number of vehicles)



Source: Congressional Budget Office based on Colonel William Sheehy, "HBCT Industry Day Brief," October 10, 2011.

Note: An armored combat brigade is a unit of about 3,800 soldiers, equipped with armored vehicles such as tanks, armored infantry fighting vehicles, armored personnel carriers, and self-propelled howitzers.

a. Includes recovery and armored Knight vehicles.

b. Includes cavalry, engineer, and fire support vehicles.

the [armored combat brigades] for protection, survivability,... mobility, and lethality."<sup>29</sup> He also stated that in the event of future constraints on available resources, the Army intends to continue to fund the GCV program fully.

The GCV program is planned as a replacement for a small portion of the Army's equipment but could demand a significant share of the service's annual resources for procurement. Given the current budgetary climate and despite its high priority, it is unclear whether the Army can afford to develop and purchase the GCV, even in the relatively small quantities that the service currently envisions.

29. Answers for the record, by Robert Lennox, Deputy Chief of Staff of the Army for financial management, submitted subsequent to the hearing on Army Acquisition and Modernization Programs before the Subcommittee on Tactical Air and Land Forces of the House Committee on Armed Services (October 26, 2011), <http://go.usa.gov/4cWV>.

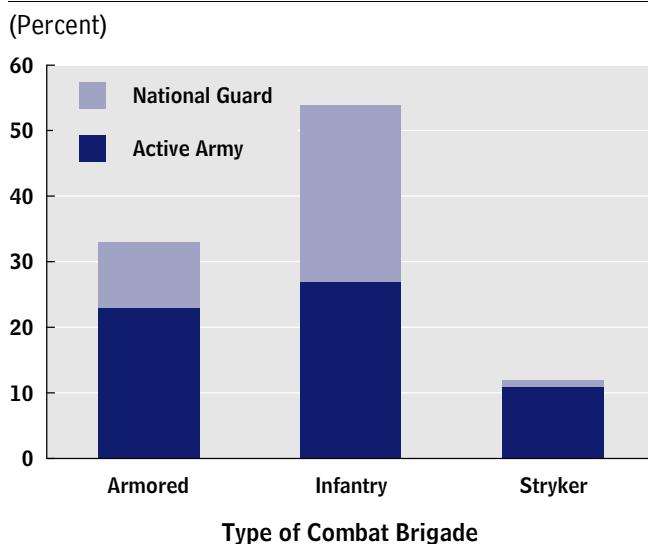
**Scope.** As the GCV program is now constituted, the new vehicle would replace only a fraction of the Army's combat equipment. And some analysts assert that the vehicles slated for replacement are not those that should be first in line. Specifically, according to the Army's current plan, the GCVs will replace the 61 Bradley vehicles that are configured as IFVs in each of the Army's armored combat brigades. Those vehicles represent only a small portion—18 percent—of the 346 armored combat vehicles in each armored combat brigade (see Figure 1-2).<sup>30</sup> Moreover, armored combat brigades made up only one-third of the Army's total combat brigades at the end of 2012 (see Figure 1-3).<sup>31</sup>

Furthermore, the GCVs are scheduled to replace vehicles that are far from the oldest armored vehicles in the armored combat brigades. The more numerous M113-based vehicles—which constitute more than 30 percent of the armored combat vehicles in an armored combat brigade—are far older, both in terms of age of design and chronological age. The M113 was designed in the wake of the Korean War as an armored personnel carrier intended to protect soldiers from small-arms fire, artillery fragments, and the effects of nuclear weapons. Those vehicles are not worth upgrading, in the Army's estimation, and the service stopped doing so in 2007. As a result, the Army's M113-based vehicles were, on average, 13 years old at the end of 2012.

In contrast, the Army's Bradleys are much newer, both in terms of design and average age. Although the Bradley fighting vehicle was originally designed in the 1970s, the basic model has been upgraded and modernized several times since then. As a result, all of the current Bradley vehicles have been upgraded since 1996, and most have received additional improvements designed to increase

30. Each armored combat brigade includes 57 additional Bradley vehicles that are configured to scout out enemy forces and perform reconnaissance missions, spot potential targets for artillery, and support the brigade's engineers.

31. At the end of 2012, armored combat brigades made up 38 percent of the combat brigades in the active Army and 25 percent of the combat brigades in the Army National Guard. Changes in the Army's force structure during the next five years may change the mix of combat brigades in the Army, but it is unlikely that their share will increase.

**Figure 1-3.****Distribution of Army Combat Brigades at the End of 2012**

Source: Congressional Budget Office based on Army data.

Note: Combat brigades include roughly 3,400 to 4,200 soldiers. Armored combat brigades, which have roughly 3,800 soldiers, are equipped with armored vehicles, such as tanks and armored infantry fighting vehicles. Stryker combat brigades, which have about 4,200 soldiers, are equipped with several variants of the Stryker vehicle, such as infantry carriers and command and control vehicles. Infantry combat brigades, which have 3,400 to 3,500 soldiers, are not equipped with any armored combat vehicles.

protection and survivability in the years since 2005.<sup>32</sup> Furthermore, because of the extensive recapitalization program that the Army undertook for equipment brought back from Iraq, the Bradley IFVs that the GCVs are slated to replace were less than seven years old, on average, at the end of 2012.<sup>33</sup> Thus, in its focus on the GCV program, the Army has placed a higher priority on replacing some of its most capable and newly rejuvenated

32. Most of the Bradley vehicles in units in the active Army include improvements introduced since 2005. Some of the Bradley vehicles used by the National Guard may be older models introduced in the 1990s.

33. The Army's recapitalization program included the total overhaul—and, in some cases, an upgrade—of vehicles brought back from Operation Iraqi Freedom. As a result, most of the Army's Bradley IFVs have been restored to an "as-new" condition at some point during the past seven years.

combat vehicles—the Bradley IFVs—and assigned a lower priority to replacing its much older and more vulnerable M113-based vehicles.<sup>34</sup>

**Affordability.** Even if the Army could deliver GCVs at the cost per unit now projected, the affordability of the GCV program is still in question, given that the service's future resources are likely to be restricted. In January 2013, recognizing that the program as originally structured might not be affordable, the Undersecretary for Defense for Acquisition, Technology, and Logistics directed the Army to restructure its program to reduce the funding that it would require from 2014 through 2018.<sup>35</sup> Specifically, he directed the Army to contract with one company, rather than two, to carry out the engineering and manufacturing development portion of the program and to delay the start of production by one year. Together, those changes would reduce funding required for the GCV program from 2014 through 2018 by almost \$4 billion, according to estimates from the Department of Defense.<sup>36</sup> (The nearly \$1.5 billion saved during that period by deferring the start of production by one year would not yield any savings over the life of the program, however. That cost would merely be deferred to the years after 2018.)

The large amounts of funding needed for the GCV program when the vehicle goes into production—probably at least \$2 billion annually for the 2019–2028 period—would limit the funds available for the service's other programs.<sup>37</sup> If the Army's procurement budget remained at the amount that the service has estimated for 2017

34. The Army's Armored Multi-Purpose Vehicle Program is designed to replace the M113-based vehicles in armored combat brigades, but it is of lower priority—in terms of modernization efforts—than the GCV program.

35. Frank Kendall, Undersecretary of Defense for Acquisition, Technology, and Logistics, acquisition decision memorandum to the Secretary of the Army, January 16, 2013.

36. Frank Kendall, Undersecretary of Defense for Acquisition, Technology, and Logistics, informational memorandum to the Deputy Secretary of Defense, January 16, 2013. Estimates of savings included in the memorandum—more than \$4 billion from 2014 through 2018—are expressed in nominal dollars.

37. Although the Army spent \$2.2 billion to \$3.7 billion annually to purchase hundreds of tanks each year from 1981 to 1989, it has not devoted \$2 billion annually for several consecutive years to a single program since then.

(according to documents associated with the President's 2013 budget request) through 2030, the large sums needed for the GCV program in each of the years from 2020 through 2028 would absorb 10 percent or more of the Army's annual procurement funds in those years.<sup>38</sup>

The Army has other pressing investment needs, even within its own combat vehicle fleet. The service has concluded that its M113-based vehicles are not worth

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38. The Army has not devoted more than 10 percent of its procurement funds to any one program since 1990, when the Apache helicopter program received 11 percent of the service's annual procurement budget.

improving and must be replaced soon. The rest of the Army's armored combat vehicles have been reconditioned or upgraded in the past 15 years as they were prepared for or returned from operations in Iraq. As armor and new electronic devices were added to tanks and Bradley fighting vehicles to protect soldiers from IEDs and other weapons in Iraq, the capacities of the electrical systems and power trains of its combat vehicles were pushed to their limits. As a consequence, the Army will need to spend a significant amount on modifying its Abrams tanks, the Bradley fighting vehicles that remain in service, and other combat vehicles so that they can continue to perform for another 20 years.



## Alternatives to the Ground Combat Vehicle Program

**T**he Congressional Budget Office has examined four alternatives to the Army's current plans for modernizing some of its combat vehicles. Each would cancel the Army's planned Ground Combat Vehicle program, and three of the four would field new or upgraded vehicles.<sup>1</sup> The four alternatives are as follows:

- Option 1: Purchase the Israeli Namer armored personnel carrier.
- Option 2: Develop and procure an upgraded version of the current Bradley Infantry Fighting Vehicle that would incorporate a larger engine and improved drivetrain along with upgraded electronic and communications equipment.
- Option 3: Purchase the German Puma IFV.
- Option 4: Field no new vehicles after canceling the Army's GCV program. Under this option, the Army would maintain the capability of the current Bradley IFV fleet through a life-extension program and a low-level research and development effort to investigate future improvements.

Under CBO's Options 1, 2, and 3, the Army would purchase enough vehicles to equip its armored combat brigades on the same schedule that CBO assumed it would follow for purchasing the GCV—that is, beginning in 2019 and ending in 2030.<sup>2</sup> Each option would involve purchasing enough vehicles to ensure that every mechanized infantry platoon would have sufficient passenger

1. In August 2011, the Undersecretary of Defense for Acquisition, Technology, and Logistics asked the Army to evaluate a similar list of options, including the Israeli Namer APC and versions of the Bradley IFV. Although the German Puma was not mentioned at the time, the Army is evaluating it and the Swedish CV9035 IFV as alternatives to the GCV.

seating among its vehicles for a minimum of 28 soldiers—three 9-member infantry squads and the platoon leader (see Table 2-1).

The GCV schedule includes a delay of three years between the initial purchase of GCVs and their assignment to Army units. Thus, it is likely that 2022 would be the first year in which an Army unit could be equipped with a new or improved vehicle and realize the benefits of the improvement, and it would probably be 2032 before the Army could field the full fleet in its various units.

CBO compared the options on the basis of the vehicles' acquisition cost, programmatic risk, and improvements offered in a set of basic capabilities (see Table 2-2).<sup>3</sup> To make comparisons, CBO used the same two metrics that it used to evaluate the GCV's capabilities, examining the combined improvements offered by each vehicle in four categories: protection and survivability, lethality, mobility, and passenger capacity. (See the appendix for a discussion of CBO's methodology.) For mobility and passenger capacity, CBO had enough data to make its own comparisons of the vehicles' capabilities with those of the

2. Because the Namer and Puma are already developed and being produced overseas, it is conceivable that purchases could begin before 2019. For ease of analysis, however, CBO assumed that all vehicles examined in the options would be purchased on the same schedule.

3. For each option, CBO estimated the acquisition cost only—that is, the cost of research and development and procurement. As a basis for comparing the capabilities of the GCV with those of the other vehicles, CBO used the Army's notional version of the GCV, known as the GCV Design Concept After Trades, which was described in Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives*, Tab B, "Ground Combat Vehicle Trade Impact Analysis" (March 2011).

**Table 2-1.****Passenger Capacity of Combat Vehicles Under the Army's Plan and CBO's Options**

	Army's Plan <sup>a</sup> (Field the GCV)	CBO's Options			
		1. Purchase Israeli Namer APC	2. Upgrade Bradley IFV	3. Purchase German Puma IFV	4. Retain Current Bradley IFV <sup>b</sup>
Vehicles per Platoon	4	4	4	5	4
Seating Capacity per Vehicle					
Crew	3	3	3	3	3
Passengers	9	9 <sup>c</sup>	7	6	7
Allocation of Passenger Seats per Platoon					
Platoon members	28	28	28	28	28
Accompanying soldiers <sup>d</sup>	8	8	0	2	0
Total	36	36	28	30	28

Sources: Congressional Budget Office based on Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives* (March 2011); Department of the Army, personal communication to CBO staff, December 2012; and other sources.

Note: GCV = Ground Combat Vehicle; APC = armored personnel carrier; IFV = infantry fighting vehicle.

- Based on the December 2010 version—the Design Concept After Trades—of the GCV after additional design trade-offs that the Army made to reduce the average procurement unit cost to \$13.5 million (in 2013 dollars).
- Version of the M2A3 Bradley IFV used in Iraq, which includes reactive armor and underbelly armor.
- The Namer can carry nine passengers and a crew of two or three, depending on the configuration of the seats.
- Space available for medics, radio operators, or other soldiers who are not members of the platoon but who habitually accompany the platoon on missions.

current Bradley IFV; for lethality and protection and survivability, the agency used results from the Army's analyses of the various vehicles to compare capabilities.<sup>4</sup>

CBO also compared the total passenger carrying capacity that each option would provide to an individual platoon. The vehicles that CBO evaluated carry different numbers of passengers: The Namer APC can carry nine, the upgraded Bradley IFV can carry seven, and the Puma IFV can carry six (see Figure 2-1 on page 22).<sup>5</sup> To provide a minimum carrying capacity of 28 passengers for each

- Although the Army's analysis depended in part on computer simulations of combat, the technical data were insufficient to simulate the performance of the Namer or the Puma. Instead, the Army's analysts estimated how those two vehicles would have performed relative to the current Bradley IFV. The analysis is discussed in Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives* (March 2011).
- Although earlier Army reports concluded that the Puma could accommodate seven passengers, more recent data indicate that it can transport only six.

platoon, Options 1 and 2 would field four vehicles per platoon, the same as that for the current Bradley IFV and as planned for the GCV. Option 3 would field five Pumas per platoon. The consequences of the different seating capacities and equipping strategies are addressed below.

The programmatic risk associated with each option that involves purchasing new or upgraded vehicles depends on several factors, including whether a vehicle is produced currently and whether it is being produced for the U.S. Army. The risk that a program's cost will rise or its schedule will lengthen generally diminishes as a vehicle approaches production. So, although there is always a risk associated with integrating a vehicle produced for a foreign army into U.S. forces, the cost and schedule risks associated with purchasing the Namer and the Puma would be considered low because those vehicles are already in production outside the United States. The risk associated with the GCV program, by contrast, would be high because that vehicle is in the early stages of development and several years will elapse before it reaches production. There is virtually no programmatic risk associated with retaining the current Bradley IFV.

**Table 2-2.**

## Total Cost, Programmatic Risk, and Improvement in Capabilities Under the Army's Plan and CBO's Options

Army's Plan <sup>a</sup> (Field the GCV)	CBO's Options			
	1. Purchase Israeli Namer APC	2. Upgrade Bradley IFV	3. Purchase German Puma IFV	4. Retain Current Bradley IFV <sup>b</sup>
Total Cost, 2014 to 2030 (Billions of 2013 dollars)	28.8 <sup>c</sup> High	19.5 <sup>c</sup> Low	19.5 <sup>c</sup> Intermediate	14.5 <sup>d</sup> Low
Programmatic Risk				4.6 <sup>e</sup> None
<b>Improvement in Capability in Four Categories Relative to the Current Bradley IFV (Percent)</b>				
Protection and Survivability	27	33	27	28
Lethality	-7	-36	60	103
Mobility	24	4	15	22
Passenger Capacity				
Number of occupants	29	29	0	-14
Ability to carry a full nine-member squad	100	100	0	0
<b>Overall Improvement in Combat Vehicle Capability Relative to the Current Bradley IFV (Percent)<sup>f</sup></b>				
Using Primary Metric <sup>g</sup>	16	6	32	45
Using Secondary Metric <sup>h</sup>	36	25	25	38
<b>Percentage Improvement per \$1 Billion Invested</b>				
Using Primary Metric <sup>g</sup>	0.6	0.3	1.6	3.1
Using Secondary Metric <sup>h</sup>	1.3	1.3	1.3	2.6

Sources: Congressional Budget Office based on Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives* (March 2011); and Department of the Army, personal communication to CBO staff, May 2012.

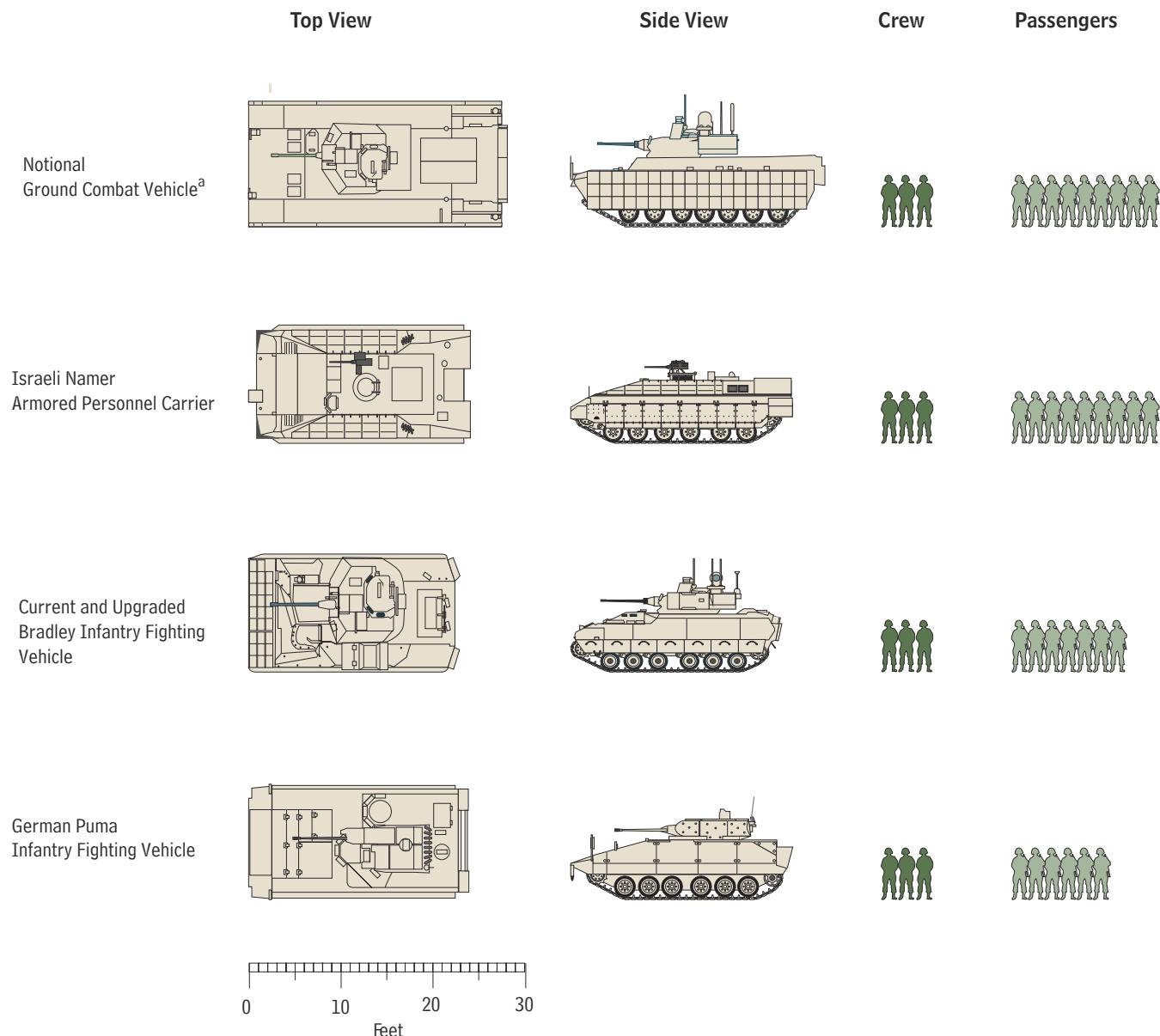
Note: GCV = Ground Combat Vehicle; APC = armored personnel carrier; IFV = infantry fighting vehicle.

- a. Based on the December 2010 version—the Design Concept After Trades—of the GCV after additional design trade-offs that the Army made to reduce the average procurement unit cost to \$13.5 million (in 2013 dollars).
- b. Version of the M2A3 Bradley IFV used in Iraq, which includes reactive armor and underbelly armor.
- c. The cost to develop and purchase 1,748 vehicles.
- d. The cost to develop and purchase 2,048 vehicles.
- e. The cost to extend the life of 820 Bradley IFVs and continue research and development.
- f. Overall improvement is based on a weighted combination of the improvement in the categories shown.
- g. CBO's primary metric determines the overall improvement in capability based on the weighting (derived from the Army's analysis) of improvements in four areas: protection and survivability (40 percent), lethality (30 percent), mobility (20 percent), and maximum number of passengers (10 percent). See the appendix for details concerning CBO's metrics.
- h. CBO's secondary metric gives equal weight to the improvement in each of the four areas in order to determine an overall increase in capability; improved passenger capacity is 100 percent for those vehicles that can carry a full nine-member squad and zero for other vehicles. See the appendix for details concerning CBO's metrics.

### Option 1: Purchase the Israeli Namer APC

Under this option, the Army would purchase the Israeli Namer APC to replace its current Bradley IFV. Specifically, the service would cancel the GCV program and

purchase 1,748 Namer APCs on the procurement schedule that CBO assumed the Army would follow for the GCV (see Table 2-3). By purchasing the Namer, the Army could save \$9 billion between 2014 and 2030 relative to the cost of fielding the GCV, and the programmatic risk would be smaller (see Table 2-2).

**Figure 2-1.****Characteristics of Selected Combat Vehicles**

Sources: Congressional Budget Office based on Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives* (March 2011); Department of the Army, personal communication to CBO staff, December 2012; and other sources.

a. Based on the December 2010 version—the Design Concept After Trades—of the Ground Combat Vehicle after additional design trade-offs that the Army made to reduce the average procurement unit cost to \$13.5 million (in 2013 dollars), as described in the Army's March 2011 report.

The Namer offers the greatest degree of protection of all the vehicles that CBO analyzed. In addition, the Namer can carry a full 9-member squad; as a consequence, a platoon equipped with four Namers would provide seating for 36 soldiers in addition to the vehicles' crews. However, because the Namer is only lightly armed, it

does not provide the lethality that the Army seeks, and its mobility is less than that of the notional GCV.

### Overview

The Namer APC is used by the Israeli army as a troop carrier and is, according to some sources, among the

**Table 2-3.****Number and Total Cost of Vehicles Developed and Purchased Under the Army's Plan and CBO's Options**

	2014–2020	2021–2025	2026–2030	Total, 2014–2030
<b>Number of Vehicles</b>				
Army's Plan and CBO's Options 1 and 2	216	780	752	1,748
CBO's Option 3	216	950	882	2,048
<b>Total Cost (Billions of 2013 dollars)</b>				
Army's Plan (Field the GCV)	9.1	10.9	8.9	28.8 <sup>a</sup>
CBO's Options				
1. Purchase Israeli Namer APC	3.5	8.6	7.3	19.5 <sup>a</sup>
2. Upgrade Bradley IFV	5.5	7.5	6.5	19.5 <sup>a</sup>
3. Purchase German Puma IFV	2.6	6.5	5.4	14.5 <sup>b</sup>
4. Retain Current Bradley IFV	0.8	1.7	2.1	4.6 <sup>c</sup>

Source: Congressional Budget Office.

Note: GCV = Ground Combat Vehicle; APC = armored personnel carrier; IFV = infantry fighting vehicle.

a. The cost to develop and purchase 1,748 vehicles.

b. The cost to develop and purchase 2,048 vehicles.

c. The cost to extend the life of 820 Bradley IFVs and continue research and development.

world's best-protected APCs, providing soldiers with protection equal to that offered by a modern main battle tank. The Namer was developed at least partly in response to long-range attacks by antitank missiles during fighting in Lebanon in 2006. After observing that heavy tanks were the only vehicles that could protect occupants from such attacks, the Israeli Ministry of Defense developed the Namer—a troop carrier that is a turretlless version of the Israeli Merkava tank. The first Namer was delivered to the Israeli army in 2008, and two were in combat in Gaza that year. Ultimately, the Israeli army expects to field about 250 Namers as replacements for its older APCs.

The primary goal of the Namer's design is to protect its occupants, and it is equipped with more armor, particularly underneath, than the other vehicles that CBO evaluated. "Floating" seats, which have no direct contact with the floor, protect occupants against blasts that come from below the vehicle, and the advanced armor protects against attacks from the front, the sides, and overhead. The Namer's primary weapon is a 12.7 millimeter heavy machine gun that can be operated from inside the vehicle, but a manually operated 7.62 mm machine gun also can be mounted on the roof (see Table 2-4). The Namer is built on a tank chassis and, depending on its armor configuration, weighs 68 to 70 tons—almost as much as

an Abrams tank. Its large, 1,200 horsepower diesel engine enables it to traverse difficult terrain.

Although the Namer is better protected than the current Bradley IFV, it has less firepower. Army experts estimated the Namer's likely performance in combat and concluded that, relative to the Bradley, the APC's extensive armor would result in 33 percent fewer losses of U.S. personnel and vehicles in combat. But the same experts also concluded that the lightly armed Namer would destroy significantly fewer enemy personnel and vehicles during combat, yielding a reduction in lethality of 36 percent relative to the Bradley. Although the Namer's mobility is 4 percent greater than that of the current Bradley IFV, its mobility would be less than the GCV's because of its slow acceleration and slower off-road speeds.

Using its primary metric for evaluation, CBO estimated that the vehicle would provide only a slight improvement—6 percent—in overall capability relative to the current Bradley IFV (see Figure 2-2). But because the Namer can carry a full nine-member infantry squad, it would provide a 25 percent improvement by CBO's secondary metric, which emphasizes passenger capacity.

According to the Army's assessments, the Namer would be superior to the current Bradley IFV in its ability to

**Table 2-4.****Characteristics of Combat Vehicles Under the Army's Plan and CBO's Options**

Army's Plan <sup>a</sup> (Field the GCV)	CBO's Options			
	1. Purchase Israeli Namer APC	2. Upgrade Bradley IFV	3. Purchase German Puma IFV	4. Retain Current Bradley IFV <sup>b</sup>
<b>Physical Characteristics</b>				
Weight (Tons) <sup>c</sup>	50 to 65	68 to 70	35 to 41	35 to 47
Dimensions (Feet)				
Length	28	24	23	24
Width	13.7	13.1	12.8	12.2
Height	13.7	9.0	11.1	10.0
Engine Capacity (Horsepower)	1,500	1,200	800	1,073
<b>Armament</b>				
Cannon (Caliber in mm)	25	n.a.	25	30
Antitank Missile	n.a.	n.a.	TOW	Spike <sup>d</sup>
Machine Gun (Caliber in mm)				
RCWS	12.7	12.7	7.62	n.a.
Coaxial	7.62	n.a.	7.62	5.56
				7.62

Sources: Congressional Budget Office based on Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives* (March 2011), and other sources.

Note: GCV = Ground Combat Vehicle; APC = armored personnel carrier; IFV = infantry fighting vehicle; mm = millimeters; TOW = tube-launched, optically tracked, wire-guided; RCWS = remotely controlled weapon station; n.a. = not applicable.

- a. Based on the December 2010 version—the Design Concept After Trades—of the GCV after additional design trade-offs that the Army made to reduce the average procurement unit cost to \$13.5 million (in 2013 dollars).
- b. Version of the M2A3 Bradley IFV used in Iraq, which includes reactive armor and underbelly armor.
- c. The lower end of the range represents the weight of the vehicle without added armor or other protective measures. The upper end includes the weight of currently proposed protective equipment that could be or has been added to the vehicle.
- d. The Spike antitank guided missile was developed by Rafael Advanced Defense Systems in Israel, which produces it for domestic and international sales outside of Europe. EuroSpike GmbH, a consortium of two German companies and a Dutch holding company owned by Rafael, produces the missile for sales to European countries.

accommodate future improvements that could add weight and require more electrical power. Among the vehicles that CBO considered, the Namer is exceeded only by the GCV in that area.

### Cost

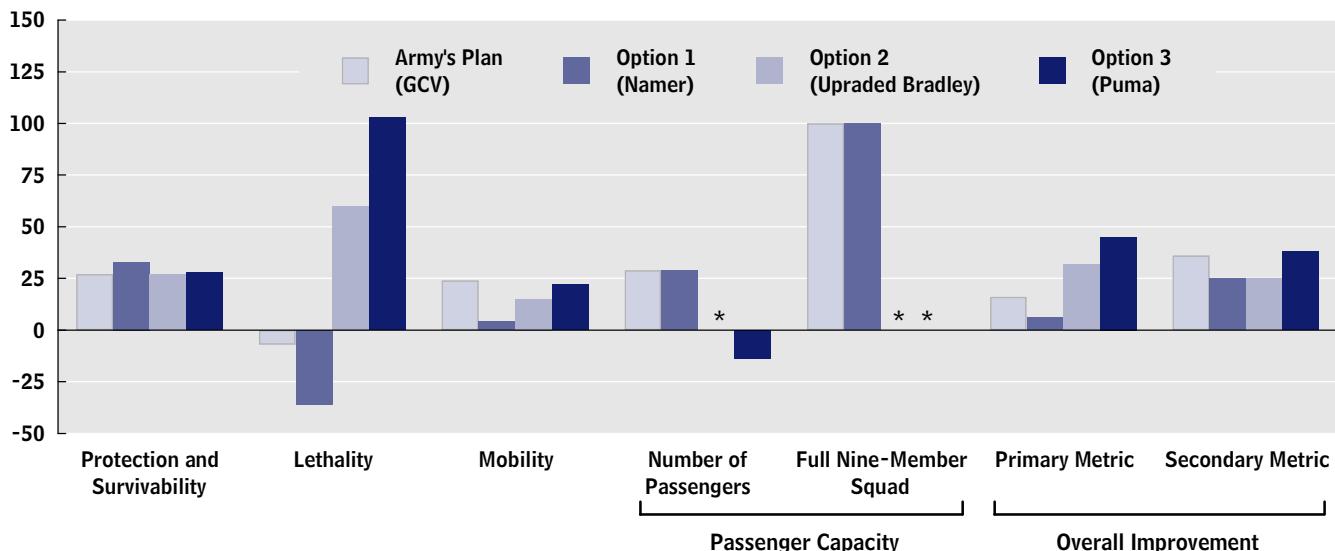
The projected cost of this option—\$19.5 billion from 2014 through 2030—would be \$9 billion less than the cost of the Army's planned GCV program. Because the Namer is already in production, adapting it for the U.S. Army should be relatively inexpensive. CBO assumed that development would cost about \$300 million, and that most of the cost of the option would be for procurement of 1,748 Namer vehicles, at an average unit cost of \$11.0 million.

### Advantages and Disadvantages

The Israeli Namer APC is alone among the alternative vehicles that CBO considered in meeting the Army's goal of carrying a full nine-member squad along with a crew. The vehicle offers three other important advantages over the Army's planned GCV: First, the advanced armor and the design of the underbelly would provide better protection for occupants than would be afforded by the notional GCV or any other vehicle that CBO examined. Second, at roughly \$20 billion over the 2014–2030 period, the expected cost of this option is about \$9 billion less than the expected cost of the GCV program. And third, purchasing the Namer should be less risky than purchasing the GCV because the Namer is already in

**Figure 2-2.****Improvement in Capabilities Under the Army's Plan and Three of CBO's Options**

(Percentage improvement relative to the current Bradley IFV)



Source: Congressional Budget Office.

Notes: The Army's plan would field the GCV, Option 1 would purchase the Israeli Namer APC, Option 2 would upgrade the Bradley IFV, and Option 3 would purchase the German Puma IFV.

For CBO's primary metric, the overall improvement in capability is based on the weighting (derived from the Army's analysis) of improvements in four areas: protection and survivability (40 percent), lethality (30 percent), mobility (20 percent), and maximum number of passengers (10 percent). For CBO's secondary metric, improvements in the same four areas are weighted equally to determine an overall increase in capability; improved passenger capacity is 100 percent for those vehicles that can carry a full nine-member squad and zero for other vehicles. See the appendix for details concerning CBO's metrics.

IFV = infantry fighting vehicle; GCV = Ground Combat Vehicle; APC = armored personnel carrier; \* = zero.

production and therefore likely to require little in the way of development.

Fielding the Namer would yield some results similar to those for the notional GCV. If each platoon was equipped with four Namers, there would be enough space to accommodate extra personnel, such as medics, from outside the platoon. And, as for the GCV, the Namer's size and weight could pose difficulties for traversing bridges in undeveloped areas, for maneuvering in urban areas, and for being transported by air or rail.

Purchasing the Namer, however, also would pose disadvantages relative to the GCV. The APC is not heavily armed; its largest weapon is a 12.7 mm machine gun, which would be considered only a secondary weapon on the other vehicles that CBO examined. Thus, the Army's experts have concluded, in combat the Namer would destroy many fewer enemy personnel and vehicles

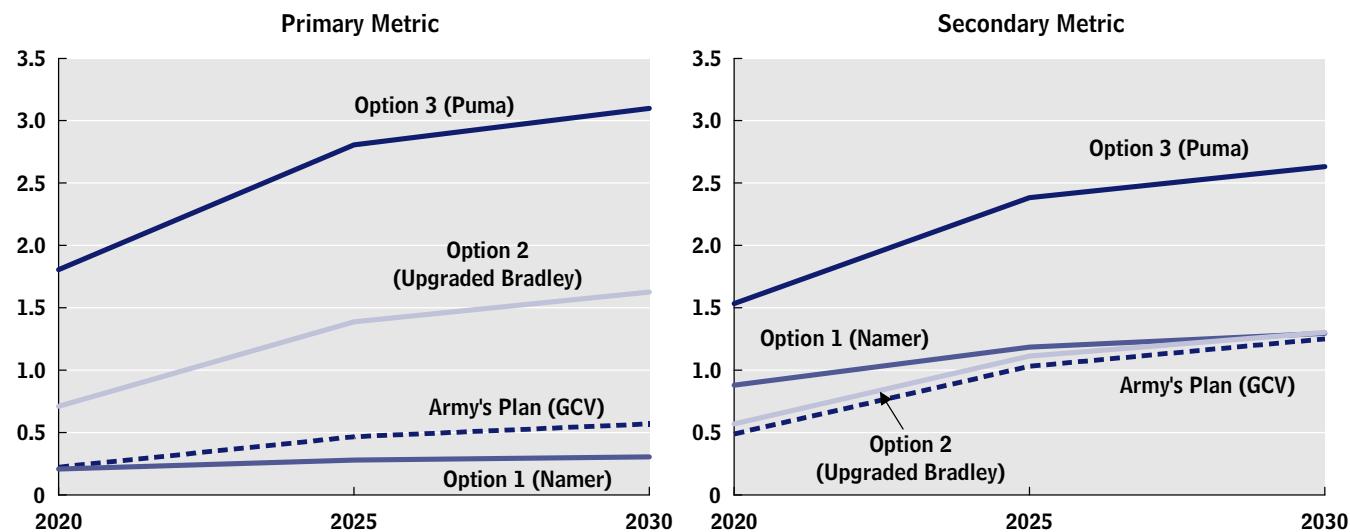
than would a GCV and even fewer than the current Bradley IFV.

Despite the superior protection and survivability the Namer offers—and its larger capacity for passengers—according to CBO's primary metric, the Namer is only 6 percent better overall than the current Bradley IFV. Because of that small advantage, the cost-effectiveness of this option—a 0.3 percent increase in capability for each \$1 billion spent—also would be the least of all options that involve new or upgraded vehicles (see Figure 2-3). According to CBO's secondary metric, however, the Namer would offer roughly the same increase in capability per \$1 billion invested as would be offered by the GCV (1.3 percent).

In addition, the ability of the Namer to protect its occupants may have been overstated in the Army's estimates. As part of its examination of alternatives before the beginning of technology development for the GCV, the

**Figure 2-3.****Cost-Effectiveness of the Army's Plan and Three of CBO's Options**

(Percentage overall improvement relative to the current Bradley IFV fleet per \$1 billion invested)



Source: Congressional Budget Office.

Notes: The Army's plan would field the GCV, Option 1 would purchase the Israeli Namer APC, Option 2 would upgrade the Bradley IFV, and Option 3 would purchase the German Puma IFV.

For CBO's primary metric, the overall improvement in capability is based on the weighting (derived from the Army's analysis) of improvements in four areas: protection and survivability (40 percent), lethality (30 percent), mobility (20 percent), and maximum number of passengers (10 percent). For CBO's secondary metric, improvements in the same four areas are weighted equally to determine an overall increase in capability; improved passenger capacity is 100 percent for those vehicles that can carry a full nine-member squad and zero for other vehicles. See the appendix for details concerning CBO's metrics.

IFV = infantry fighting vehicle; GCV = Ground Combat Vehicle; APC = armored personnel carrier.

Army assumed that the Namer's protective capability would be enhanced by an active protection system of as-yet-undemonstrated effectiveness and reliability.<sup>6</sup> However, in 2010, the Israeli Ministry of Defense scrapped its original plans to install an active protection system on the Namer. If the Army's assessments of the Namer relied on an assumed degree of effectiveness of the Namer's active protection system, those assessments may yield an overly optimistic picture of the Namer's true protective capability.

6. CBO's analysis was based on the characteristics of the Namer, the upgraded and current versions of the Bradley IFV, and the Puma that were included in Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives*, Tab D, "Ground Combat Vehicle AoA Systems Book" (March 2011). Those characteristics do not reflect insights that the Army may have gained during its evaluation of nondevelopmental vehicles in the summer and fall of 2012.

One final disadvantage of this option is that it involves fielding a foreign-made system that, although already developed and in use by an ally, would need to be integrated into the Army's logistics system. Nevertheless, establishing full or partial manufacturing of the vehicle in the United States might not be an obstacle. A U.S. company has already negotiated a contract with the Israeli Ministry of Defense to manufacture an unspecified number of Namer vehicle hulls and other components for the Israeli army at a production facility in the United States.

**Option 2: Upgrade the Bradley IFV**

Under this option, the Army would cancel the GCV program and instead upgrade its existing Bradley IFVs. Specifically, the Army would purchase 1,748 upgraded Bradley IFVs on the procurement schedule that CBO assumed for the GCV and the Namer. CBO estimates that the Army would realize savings relative to the cost of

its planned GCV program of \$9 billion between 2014 and 2030 (see Table 2-2 on page 21). In addition, by CBO's primary metric, the Army would gain an expected improvement in capability relative to the current IFV of 32 percent, with less programmatic risk than that associated with the GCV program. Nevertheless, under this option, some of the Army's goals would remain unmet. According to CBO's secondary metric, which emphasizes a vehicle's ability to carry a nine-member squad, fielding the upgraded Bradley IFV would yield a 25 percent improvement in capability relative to the current IFV.

### Overview

An upgraded Bradley IFV would confer several improvements relative to the current Bradley IFV: a more powerful engine, an improved suspension, additional armor under the vehicle and more effective reactive armor tiles, improved optical systems for acquiring and tracking targets, and an extra 7.62 mm machine gun that could be operated from inside the vehicle.<sup>7</sup>

Taken together, the improved suspension and added armor and tiles would significantly increase the protection afforded to the Bradley IFV's occupants. The improved suspension would allow the vehicle to ride higher off the ground, even though with the upgrades the vehicle would weigh about 2 tons more than the current Bradley IFV. The increased ground clearance, when combined with the added armor on the underside of the vehicle, would offer greater protection against mines.

All of those enhancements would confer a significant increase in the upgraded Bradley's capabilities relative to those of the current IFV. Results from the Army's combat simulations indicate that the improved protection of the vehicle's occupants and the survivability of the vehicle

7. Reactive armor mitigates damage to vehicles. The most common type consists of explosives placed between two metal plates. When incoming munitions penetrate the outer metal plate, the explosives detonate, and the outer metal plate flies off to destroy or deflect the incoming round. Typical reactive armor consists of modules or tiles attached to the outside of the vehicle. Although the armor can be added to an existing vehicle, that vehicle must have sufficient support structure and armor to withstand the explosion of the tiles. The Army has developed and deployed reactive armor for its Bradley fighting vehicles, Abrams tanks, and Stryker vehicles. For a discussion, see Bernard Kempinski and Christopher Murphy, *Technical Challenges of the U.S. Army's Ground Combat Vehicle Program*, Working Paper 2012-15 (Congressional Budget Office, November 2012), pp. 55-56, [www.cbo.gov/publication/43699](http://www.cbo.gov/publication/43699).

itself would reduce losses by 27 percent overall. In addition, the added machine gun and the improved optical systems would render the upgraded Bradley IFV more lethal than the current version. In the Army's simulations, the upgraded Bradley was 60 percent more effective at destroying enemy personnel and vehicles than the current Bradley IFV. Finally, the upgraded Bradley IFV's larger engine and improved suspension would result in a 15 percent increase in mobility compared with the current version.

### Cost

In CBO's estimation, fielding an upgraded Bradley IFV as described above would cost \$19.5 billion from 2014 through 2030. Of that amount, \$2.7 billion would be needed from 2014 through 2019 to develop and integrate the technologies that would improve the Bradley's protection, mobility, and lethality. The remaining funds—\$16.8 billion—would be needed to purchase 1,748 vehicles at an average unit cost of \$9.6 million.

### Advantages and Disadvantages

This option would offer several advantages over the Army's plan: First, upgrading the fleet would cost about \$9 billion less than implementing the GCV program. Second, because the vehicle already exists, there would be no need to develop an entirely new logistics stream for spare parts or procedures for maintenance. And third, upgrading the existing vehicle would be less risky than developing an entirely new GCV.

Although the upgrades to the Bradley IFV would themselves require significant development, assessments that the Army made in 2010 showed that the needed technology was more mature than the technology required for the GCV. Moreover, although undertaking an upgrade of existing vehicles would pose some risk for cost growth, the fact that a vehicle has already been produced should moderate that risk compared with that for a new vehicle, such as the GCV.

The upgraded Bradley IFV would offer several operational advantages over the current Bradley, including an estimated overall improvement in capability of 32 percent according to CBO's primary metric. That increase is twice as large as the increase attributable to the Army's design of the GCV. An upgraded Bradley IFV would provide roughly the same protection and significantly more lethality than the notional GCV. Fielding a smaller, lighter upgraded Bradley also would allay some concerns

that have been raised about whether the GCV could maneuver easily in cities, traverse some bridges, and be easily transportable on foreign rail networks.<sup>8</sup>

Despite the estimated improvement in capability to be gained in an upgraded Bradley IFV, the vehicle would not meet several of the Army's goals for an infantry fighting vehicle as well as the GCV would. The vehicles would carry only seven soldiers apiece, so infantry squads would need to be spread among the four vehicles in a platoon—as is the case for the current Bradley IFV. Although sufficient to carry three nine-member squads and the platoon leader, the four vehicles assigned to each platoon would not be able to carry additional soldiers from outside the platoon. Instead, medics and radio operators that accompany the platoon would have to do so in their own vehicles, as they do today.

In part because the upgraded Bradley would carry fewer squad members than the GCV, it would represent a smaller improvement compared with the current Bradley IFV than the potential increase attributable to the GCV—25 percent versus 36 percent—when gauged using CBO's secondary metric. The upgraded Bradley would also fall short of the GCV in other areas, according to the Army's assessments: It would be harder to improve in the future because of its relatively smaller interior and smaller capacity for increased electrical supply and equipment, and its communications and networking features might not be as capable as the GCV's.

Yet if upgrades to the current Bradley IFVs are judged on the basis of the investment needed to carry out the option (\$19.5 billion) and on the degree of improvement such an approach would provide, they would be more cost-effective than adopting the Army's plan. CBO estimates that, on the basis of its primary metric, this option would deliver an improvement of 1.6 percent for every \$1 billion of investment—almost three times the percentage improvement (0.6 percent) for every \$1 billion invested under the Army's plan to purchase the GCV. When compared using CBO's secondary metric, the upgraded Bradley IFV would yield a 1.3 percent improvement per \$1 billion investment, the same as the GCV.

8. The Army's GCV designs have been too wide or too tall to fit through railroad tunnels in Europe and South Korea without substantial disassembly.

## Option 3: Purchase the German Puma IFV

As a third option, the Army could purchase German Puma IFVs instead of developing and purchasing GCVs. Specifically, the Army would purchase 2,048 Puma vehicles from 2019 through 2030 at a cost that CBO projects would be \$14 billion less than the cost of the Army's current plan (see Table 2-2 on page 21). The Puma also poses a lower programmatic risk of cost growth and schedule delays. Moreover, by some measures, the Puma is the most capable of the vehicles that CBO evaluated, although it would not meet all of the Army's objectives for its future IFV.

### Overview

The Puma, like the Bradley IFV and the GCV, is a true infantry fighting vehicle. Its development as a replacement for the German Marder vehicle began in the 1990s, production began in 2008, and the first vehicles were delivered to the German Army in 2011. The Puma is equipped with a 30 mm cannon, it has a 5.56 mm machine gun as a secondary weapon, and it carries a launcher for Spike antitank guided missiles, all of which are mounted on an unmanned turret.<sup>9</sup>

The Puma was designed to accommodate various kinds of armor (as is the notional GCV). The base vehicle—without additional armor—weighs 35 tons. The proposed armor package, which provides greater protection, adds 12 tons to the gross weight. The vehicle's underbelly is protected by armor against mines and improvised explosive devices. Like the Namer, the Puma has floating seats to protect passengers and crew from explosions under the vehicle.

Because the Puma can carry only 6 passengers, a platoon equipped with four vehicles could not transport three 9-member squads and a platoon leader. To carry 27 soldiers and the platoon leader—a total of 28 people—a platoon would need at least 5 Pumas. Under this option, therefore, the Army would purchase

9. The Spike antitank guided missile was developed and is produced for domestic and international sale outside Europe by Rafael Advanced Defense Systems in Israel. EuroSpike GmbH, a consortium of two German firms and a Dutch holding company owned by Rafael, produces the Spike for sale to European countries.

2,048 vehicles, 300 more than would be purchased under the Army's plan or under Options 1 and 2.<sup>10</sup>

By CBO's primary metric, the Puma would confer an estimated improvement in capability of 45 percent relative to the current Bradley IFV. The Puma's cannon (30 mm) is larger than the one on the Bradley IFV (25 mm), and it has a greater effective range against all types of targets. Thus, the Puma was assessed by Army experts to be 103 percent more lethal than the current Bradley IFV.<sup>11</sup> Its modern modular armor and higher ground clearance make it better protected than the current Bradley IFV. Consequently, the Army's experts concluded that U.S. forces equipped with the Puma would sustain 28 percent fewer losses of occupants and vehicles in combat than would similar forces equipped with the current Bradley IFV. In addition, the Puma is 22 percent more mobile than the current Bradley IFV, which makes it roughly equivalent to the GCV in that category.

Like the current Bradley, however, the Puma cannot accommodate a full nine-member squad (it carries just six passengers). As a result, using CBO's secondary metric—which emphasizes capacity for a nine-member squad—the Puma would provide an estimated 38 percent improvement in capability relative to the current Bradley IFV, rather than the 45 percent improvement under CBO's primary metric.<sup>12</sup> Compared with the GCV, which would carry nine passengers, the Puma would provide significantly greater overall capability based on CBO's primary metric but only slightly greater overall capability based on CBO's second metric.

In other areas, the Puma's capabilities show mixed results when compared with those of the other vehicles in this analysis. Because the Puma has such a large engine and is a relatively new vehicle, the Army's analysts judged that it

could accommodate additional equipment in the future more easily than the upgraded Bradley IFV, but not as easily as the notional GCV. The relatively narrow Puma would be more maneuverable in urban streets than the larger GCV. According to the Army, the Puma's communications and networking capability would be less than that of the GCV or the upgraded Bradley IFV.

### Cost

This option would be less expensive than fielding the GCV or any new or upgraded vehicle. The average cost to procure a Puma IFV, at \$6.9 million, is below the average cost of the Namer and the upgraded Bradley IFV and almost 50 percent less than that of the GCV. Furthermore, because the Puma is already in production, CBO estimated that only \$500 million in development funds would be needed to integrate it with U.S. forces and set up a full or partial production line in the United States. Therefore, even though this option would involve purchasing almost 20 percent more vehicles than the Army's plan, its cost over the 2014–2030 period would be \$14.5 billion, CBO estimates, or \$14 billion less than the cost of the Army's planned GCV.

### Advantages and Disadvantages

This option, which features an infantry fighting vehicle of recent design, would offer several advantages over the Army's plan and some other options that CBO considered: First, by either of CBO's metrics, the Puma would provide the greatest overall increase in capability of the vehicles CBO evaluated. Second, although the least expensive of the options, the Puma would provide a significant improvement in the Army's IFV fleet. Third, when judged against the current Bradley IFV, the Puma would provide the greatest increase in capability per dollar invested, regardless of the metric used. And fourth, because the Puma is already being produced, its adoption would pose a relatively lower programmatic risk.

10. The 300 additional vehicles provide one additional vehicle for each of the 12 mechanized infantry platoons in each of the Army's 22 armored combat brigades and 12 for each of the 3 brigade sets stored aboard ships or overseas for contingencies.

11. Because available technical data were insufficient to simulate the performance of the Puma, the Army's analysts estimated its performance relative to the current Bradley IFV. Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives* (March 2011).

12. The Army delivered two reports that provided the Congress with assessments of the Puma (one in March 2011 and the other in the fall of 2012). According to both reports, the Puma could accommodate seven passengers, matching the Bradley IFV. Other assessments, however, show that the Puma can accommodate only six passengers, although it might be possible to add a seventh, in cramped conditions. CBO's analysis is based on a six-passenger capacity for the Puma. A change in estimated capacity from six to seven passengers would not appreciably alter CBO's quantitative results, which would show a 1 percentage-point increase in overall capability relative to the current Bradley IFV—from 45 percent to 46 percent.

The Puma does, however, have two disadvantages: It does not meet the Army's goal of capacity for a full nine-member infantry squad—indeed, it is likely to carry one passenger fewer than the current Bradley IFV—and it was developed and is produced by a foreign manufacturer. On the first issue, because Pumas can carry only six passengers, mechanized infantry platoons would need to be equipped with five vehicles, rather than four as in the other options. Five vehicles would provide the capacity to carry a total of 30 soldiers, which could include three 9-member squads, the platoon leader, and 2 additional soldiers from outside the platoon. However, each squad would be divided between two vehicles. Moreover, the Army would need to modify tactics for its mechanized platoons, because those platoons are currently equipped with four infantry fighting vehicles.

## Option 4: Cancel the GCV Program

Under this option, the Army would retain its current fleet of Bradley IFVs and spend \$4.6 billion to maintain their effectiveness through 2030 (see Table 2-2 on page 21). Specifically, the option calls for canceling the GCV program, investing a total of \$2.9 billion in procurement funds in a life extension program for the current Bradley IFVs, and spending \$1.7 billion in research and development funds that would maintain a modest effort to investigate possible upgrades to the Bradley IFV. Carrying out this option would allow the Army to retain a fleet of capable IFVs without investing in a new fleet of vehicles.

### Overview

The Army fields Bradley vehicles in several different versions in addition to its IFVs, including those that are configured to scout out enemy forces and perform reconnaissance missions, spot potential targets for artillery, and support engineers. Although the service has planned to replace its Bradley IFVs with new GCVs, its plans call for retaining other versions of the Bradley for at least 20 years. The Army fields those vehicles in numbers roughly equal to its IFV version, and although they transport fewer soldiers, they operate under the same battlefield conditions and suffer from the same vulnerabilities that affect the Bradley IFVs. Yet the Army has no plans to replace those other Bradley vehicles in the foreseeable future.

The service does have a program, however, to remedy some of the current shortcomings of all models of the

Bradley in its inventory—including the Bradley IFV. According to the Army, that modification program will invest roughly \$2 million per vehicle to improve the vehicle's tracks, suspension, power train, and electrical system so that it can accommodate the extra weight and demands for power of systems added in the past 10 years. (The cost of that program is not included in the estimates presented here.) Although those modifications will not improve the vehicles' overall capability, the Army states that they will return the Bradleys to the level of performance that the vehicles exhibited in 2000, before being modified for combat in Iraq.

### Cost

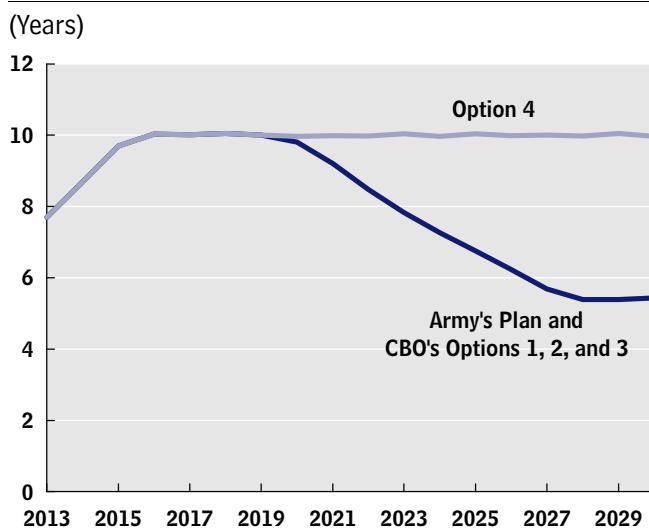
Under this option, the Army would retain all of its current Bradley IFVs and would invest \$4.6 billion to maintain their effectiveness through 2030. To prevent the average age of the Army's 1,748 Bradley IFVs from exceeding 10 years at any point between 2014 and 2030, the Army would need to rebuild roughly 820 more Bradley IFVs during that period than it would need to rebuild under its own plan or Options 1, 2, and 3.<sup>13</sup> Those activities would require \$2.9 billion, CBO estimates. In addition, the Army would invest \$100 million annually in research and development to investigate improvements to the Bradley IFV's current capabilities, for an additional cost of \$1.7 billion over that period.

### Advantages and Disadvantages

Of all the alternatives considered, the option to retain and maintain the current fleet would be the least risky and least expensive, yielding savings of almost \$24 billion compared with the cost of the Army's plan to develop and purchase the GCV. The option would involve essentially no programmatic risk because development and purchase of new or improved vehicles would not occur. And the cost of the required investment—\$4.6 billion from 2014 through 2030—would be roughly 16 percent of the cost to implement the Army's plan for the GCV. An overall goal of this option would be to maintain the capability of the current IFV fleet until the need for additional capabilities became clearer and new technologies were mature and readily available.

The option would have several disadvantages, however. Some critics have asserted that because the current

13. The Department of Defense has set a goal of maintaining the average age of its fleets of combat vehicles at 10 to 15 years.

**Figure 2-4.****Average Age of the IFV Fleet Under the Army's Plan and CBO's Options**

Source: Congressional Budget Office.

Notes: The Army's plan would field the GCV, Option 1 would purchase the Israeli Namer APC, Option 2 would upgrade the Bradley IFV, Option 3 would purchase the German Puma IFV, and Option 4 would retain the current Bradley IFV.

IFV = infantry fighting vehicle; GCV = Ground Combat Vehicle; APC = armored personnel carrier.

version of the Bradley IFV sustained significant losses from IEDs and rocket-propelled grenades in the early months of operations in Iraq, it is no longer suitable for combat. In response, however, the Army improved the vehicle to make it more survivable and better able to protect its occupants. In particular, reactive armor tiles

were added to the vehicles in 2005, and underbelly armor and electronic equipment designed to defeat IEDs were added after that. As a consequence, the number of people killed in Bradley vehicles and losses of the vehicles themselves declined substantially over the duration of the conflict.

The funding through 2030 that would be provided under this option for research to improve the Bradley IFV does not include procurement funding to incorporate any new equipment or technologies that might emerge from the research program. Therefore, the option would not increase the operational capability of the current Bradley IFV fleet. The vehicles would thus continue to suffer from the shortcomings that the GCV is meant to address: namely, the IFV's inability to carry a nine-member squad, its lack of modular armor kits and other equipment that can be adapted to meet a range of threats, and its lack of extra capacity to accept new systems that add to the vehicle's weight and the demand for electrical power.

Finally, under this option, the Army's IFV fleet would be older, on average, than under the Army's plan and Options 1, 2, or 3, because fewer new or reconditioned vehicles would be purchased. The 1,748 new vehicles purchased under the Army's plan and under Options 1 and 2, and the 2,048 vehicles purchased under Option 3, would result in an average age of the fleet of slightly more than 5 years in 2030 (see Figure 2-4). By comparison, this option would introduce just 820 as-new vehicles. Thus, from 2016 through 2030, the average age of the fleet would be 10 years.





## Appendix: CBO's Methodology for Comparing the Army's Ground Combat Vehicle and Alternatives

**T**he Congressional Budget Office (CBO) used two metrics to compare the Army's current Bradley Infantry Fighting Vehicle (IFV) with four possible alternative vehicles: the Army's planned Ground Combat Vehicle (GCV), the Israeli Namer armored personnel carrier, an upgraded version of the current Bradley, and the German Puma IFV. CBO's primary metric assessed improvements in capability, relative to the current Bradley IFV, that the GCV and the other vehicles would provide. A secondary metric also considered each vehicle relative to the current Bradley IFV but emphasized the ability to meet the Army's goal of fielding new vehicles that can carry a full nine-member infantry squad along with a crew.

Both metrics assessed the vehicles' capabilities in four categories:

- Protection of soldiers and survivability of the vehicle (the ability to withstand attacks and still continue to operate);
- Lethality (the ability to destroy enemy personnel and vehicles);
- Mobility on- and off-road, and
- Passenger capacity.

This appendix discusses CBO's measurement of the vehicles' relative capabilities in each category and how the results are combined to yield measures of overall improvement for each vehicle compared with the current Bradley IFV.

### Overall Improvement

CBO's two metrics took slightly different approaches to combining improvements across the four categories. The primary metric arrived at a measure of overall improvement by combining the improvement in each category via a weighting scheme derived from the one the Army used in its analysis of alternatives for a new GCV.<sup>1</sup> Improvements in each category were weighted on the basis of rankings given by soldiers who had been deployed with combat brigades in Iraq, Afghanistan, Kosovo, or Bosnia to the vehicle's most important characteristics. The Army's analysis included several categories that CBO assessed differently—such as cost—or excluded altogether for a variety of reasons, including an insufficiency of data for analysis of all four vehicles. Thus, the weights CBO applied for the primary metric are based on those associated with the four remaining categories of the eight categories considered in the Army's analysis (see Table A-1).

CBO's secondary metric emphasized the Army's goal of fielding vehicles that can accommodate a full nine-member squad. CBO measured improvement in the same four categories but made two changes: CBO gave equal weight to each category—thereby increasing the weight for passenger capacity from 10 percent in the primary metric to 25 percent in the secondary metric, and it used an all-or-nothing measure for passenger capacity. If the vehicle was designed to carry a full nine-member squad,

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1. Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives*, Tab I, "Ground Combat Vehicle Affordability Strategy" (March 2011).

**Table A-1.****Weights Given by the Army and CBO to Various Categories of Characteristics**

Category	Used in the Army's Analysis	Used in CBO's Analysis
Cost	0.25	n.a.
Protection and Survivability	0.20	0.40
Lethality	0.15	0.30
Mobility	0.10	0.20
Communications	0.10	n.a.
Growth Potential	0.10	n.a.
Sustainability	0.05	n.a.
Passenger Capacity <sup>a</sup>	0.05	0.10
<b>Total</b>	<b>1.00</b>	<b>1.00</b>

Source: Congressional Budget Office based on Department of the Army, Headquarters, *Report on the Results of the Ground Combat Vehicle Analysis of Alternatives (Milestone A) to the Armed Services Committees of the United States Senate and House of Representatives*, Tab I, "Ground Combat Vehicle Affordability Strategy" (March 2011).

Note: n.a. = not applicable.

a. Number of passengers.

the secondary metric gave it a full score; if it was not, the vehicle was assigned a zero for the category.

**Improvement in Individual Categories**

CBO combined the vehicles' performance in two or more specific attributes in each category to determine improvement in three categories—protection and survivability, lethality, and mobility. To arrive at scores for improvements in lethality and mobility, for example, CBO relied on the weighting schemes the Army derived in response to soldiers' survey responses. Lethality attributes included capability against enemy vehicles and effectiveness against enemy personnel. Based on soldiers' responses, by a ratio of 60 to 40, lethality against enemy vehicles was rated as more important than effectiveness against enemy personnel.<sup>2</sup> CBO also used the Army's weightings as it evaluated six attributes of mobility—rate of acceleration; off-road speed; range on a full tank of fuel; and the vehicle's turning radius, width, and weight—and combined them into a single score for mobility (see Table A-2).<sup>3</sup>

2. Department of the Army, personal communication to CBO staff, May 2012.

Reports on the Army's analysis of improvements in protection and survivability gave no indication of the relative importance ascribed by soldiers or commanders to the protection of people as opposed to the survivability of vehicles. CBO arrived at a combined increase in protection and survivability for each vehicle by assigning a weight of one-third for an improvement in survivability of the vehicle and a weight of two-thirds for an improvement in protecting soldiers.

**Improvement in Passenger Capacity**

Although both the primary and the secondary metrics assessed the passenger capacity of the vehicles—six passengers for the Puma, seven for the current and upgraded Bradley IFVs, and nine for the GCV and the Namer—the value was calculated differently for the two metrics. The primary metric used the numerical percentage increase in capacity compared with the current Bradley IFV, the reference vehicle. Thus, under the primary metric, the capacity of the GCV and the Namer is 29 percent greater than the current Bradley's, the capacity of the upgraded Bradley is the same as that of the current version, and the capacity of the Puma is 14 percent less than that of the current Bradley (see Table 2-2 on page 21). The value for capacity was combined with the values for improvement in the other three categories—each being given the appropriate weight—to determine an overall value for each vehicle (see Table A-3).

In CBO's secondary metric, which emphasized a vehicle's ability to carry a nine-member squad, each vehicle was either capable of carrying a full squad (in the case of the GCV and the Namer) or not (in the case of the Bradley IFV and the Puma). CBO therefore calculated that the vehicles increased the capacity for passengers either by 100 percent or by zero. To determine a value of the secondary metric for each vehicle, the increase in capability in the category of passenger capacity was combined with the increase in each of the other three categories, and the value for each category was given equal weight.

3. CBO chose not to include one aspect of mobility that the Army used in its analysis—long-distance transportability—because the agency did not have enough data regarding types and numbers of conveyances that would be needed to move the various vehicles long distances by rail, ship, or air. Excluding transportability increased the weights given to the other six attributes of mobility.

**Table A-2.****Weights Given by the Army and CBO to Various Mobility Attributes**

Attribute	Used in the Army's Analysis	Used in CBO's Analysis
Acceleration (Seconds) <sup>a</sup>	0.25	0.29
Average Off-Road Speed (Miles per hour)	0.20	0.24
Range on a Tank of Fuel (Miles)	0.15	0.18
Turning Radius (Feet)	0.05	0.06
Vehicle Width (Feet)	0.10	0.12
Bridge-Crossing Capacity (Tons) <sup>b</sup>	0.10	0.12
Long-Distance Transportability <sup>c</sup>	0.15	n.a.
<b>Total</b>	<b>1.00</b>	<b>1.00</b>

Sources: Congressional Budget Office and Department of the Army, personal communication, May 2012.

Note: n.a. = not applicable.

- a. Time to accelerate from zero to 30 miles per hour.
- b. Bridge weight capacity necessary to accommodate the vehicle.
- c. Ease of transporting the vehicle by rail, ship, or plane.

**Table A-3.****Weights Given to Improvement in Various Categories Under CBO's Two Metrics**

Category	Primary Metric <sup>a</sup>	Secondary Metric <sup>b</sup>
Protection and Survivability	0.40	0.25
Lethality	0.30	0.25
Mobility	0.20	0.25
Passenger Capacity	0.10	0.25
<b>Total</b>	<b>1.00</b>	<b>1.00</b>

Source: Congressional Budget Office.

Note: Improvement in capability is measured relative to that of the current Bradley infantry fighting vehicle.

- a. CBO's primary metric determines the overall improvement in capability by weighting the improvements in the four categories on the basis of soldiers' preferences.
- b. CBO's secondary metric gives equal weight to the improvement in each of the four categories in order to determine overall improvement and emphasizes a vehicle's ability to carry a full nine-member squad.

# List of Tables and Figures

## Tables

S-1. Vehicles Considered in the Army's Plan and CBO's Options	2
S-2. Capacity, Risk, Cost, and Overall Improvement in Capability Associated with the Army's Plan and CBO's Options	3
1-1. Characteristics of the Current Bradley IFV and the GCV	8
1-2. Improvement of the GCV Compared with the Current Bradley IFV	11
2-1. Passenger Capacity of Combat Vehicles Under the Army's Plan and CBO's Options	20
2-2. Total Cost, Programmatic Risk, and Improvement in Capabilities Under the Army's Plan and CBO's Options	21
2-3. Number and Total Cost of Vehicles Developed and Purchased Under the Army's Plan and CBO's Options	23
2-4. Characteristics of Combat Vehicles Under the Army's Plan and CBO's Options	24
A-1. Weights Given by the Army and CBO to Various Categories of Characteristics	34
A-2. Weights Given by the Army and CBO to Various Mobility Attributes	35
A-3. Weights Given to Improvement in Various Categories Under CBO's Two Metrics	35

## Figures

S-1. Cost and Improvement in Capability Under the Army's Plan and CBO's Options, Using Two Metrics	4
1-1. Dimensions of the Current Bradley IFV and the GCV	9
1-2. Distribution of Armored Vehicles in an Armored Combat Brigade	15
1-3. Distribution of Army Combat Brigades at the End of 2012	16
2-1. Characteristics of Selected Combat Vehicles	22
2-2. Improvement in Capabilities Under the Army's Plan and Three of CBO's Options	25
2-3. Cost-Effectiveness of the Army's Plan and Three of CBO's Options	26
2-4. Average Age of the IFV Fleet Under the Army's Plan and CBO's Options	31

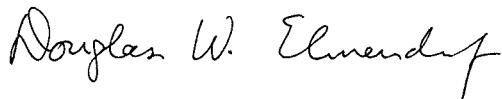
## About This Document

**T**

his Congressional Budget Office (CBO) report was prepared at the request of the former Chairman and the former Ranking Member of the Tactical Air and Land Forces Subcommittee of the House Committee on Armed Services. In keeping with CBO's mandate to provide objective and impartial analysis, the report makes no recommendations.

Frances Lussier prepared the report under the general supervision of David Mosher and Matthew Goldberg. Bernard Kempinski created the line drawings and silhouettes of the armored vehicles. Philip Webre and Derek Trunkey of CBO provided helpful comments, as did Scot A. Arnold of the Institute for Defense Analyses and Gilbert F. Decker, formerly Assistant Secretary of the Army for Research, Development, and Acquisition. (The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.)

Leah Mazade (formerly of CBO) and Kate Kelly edited the report, and Maureen Costantino and Jeanine Rees prepared it for publication. The report is available at CBO's Web site ([www.cbo.gov](http://www.cbo.gov)).



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April 2013